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Vision 2050

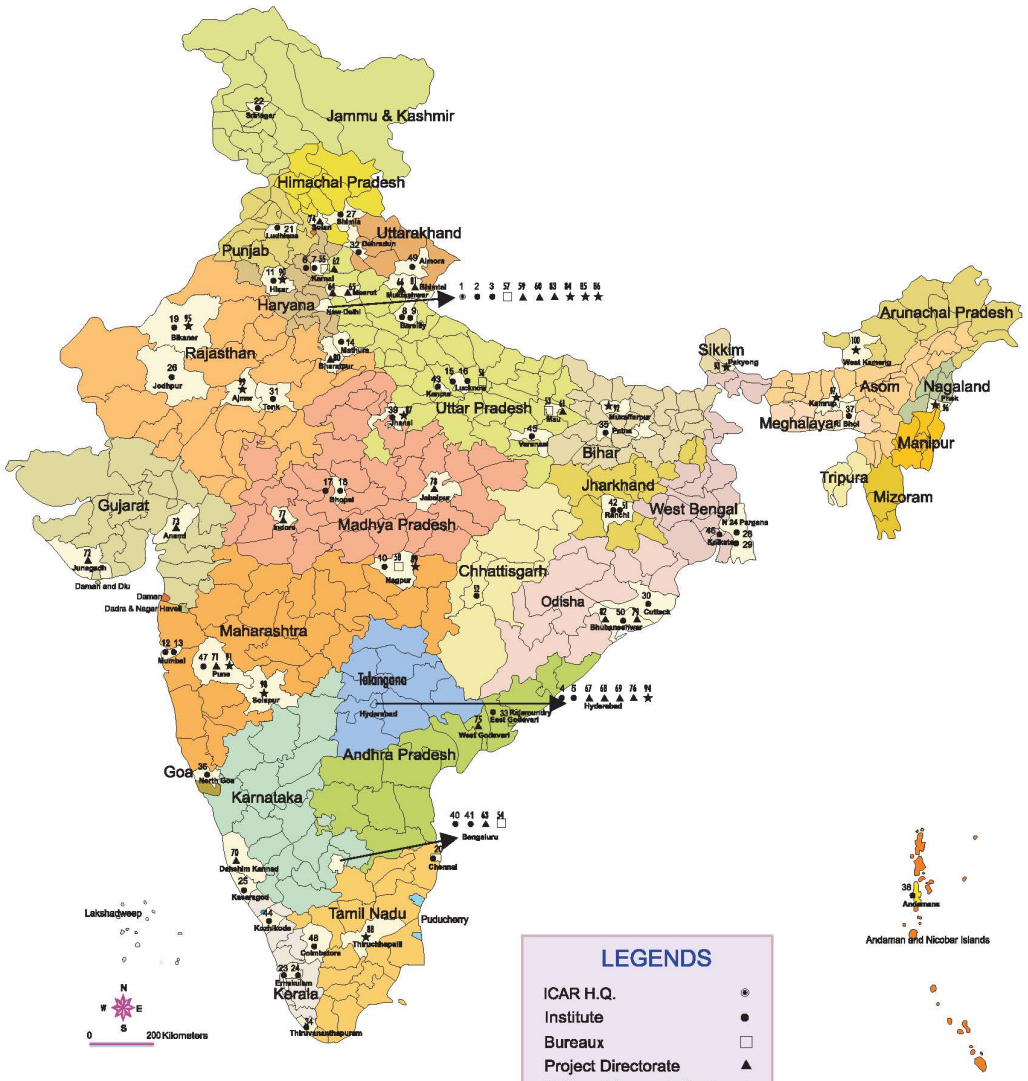
Central Institute for Research on Cotton Technology

Indian Council of Agricultural Research

ISO 9001:2008

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Institutes, Bureaux, Directorates and National Research Centres



LEGENDS

- ICAR H.Q.
- Institute
- Bureaux
- Project Directorate
- National Research Centre

● 64 Research Institutes ● 6 Bureaux ● 15 National Research Centres ● 15 Project Directorates

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

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LEGENDS

- State Agricultural Universities
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Vision 2050

ISO 9001:2008

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Printed : July 2015

संदेश

भारतीय सभ्यता कृषि विकास की एक आधार रही है और आज भी हमारे देश में एक सुदृढ़ कृषि व्यवस्था मौजूद है जिसका राष्ट्रीय सकल घरेलू उत्पाद और रोजगार में प्रमुख योगदान है। ग्रामीण युवाओं का बड़े पैमाने पर, विशेष रूप से शहरी क्षेत्रों में प्रवास होने के बावजूद, देश की लगभग दो-तिहाई आबादी के लिए आजीविका के साधन के रूप में, प्रत्यक्ष या अप्रत्यक्ष, कृषि की भूमिका में कोई बदलाव होने की उम्मीद नहीं की जाती है। अतः खाद्य, पोषण, पर्यावरण, आजीविका सुरक्षा के लिए तथा समावेशी विकास हासिल करने के लिए कृषि क्षेत्र में स्थायी विकास बहुत जरूरी है।

पिछले 50 वर्षों के दौरान हमारे कृषि अनुसंधान द्वारा सृजित की गई प्रौद्योगिकियों से भारतीय कृषि में बदलाव आया है। तथापि, भौतिक रूप से (मृदा, जल, जलवायु), बायोलोजिकल रूप से (जैव विविधता, हॉस्ट-परजीवी संबंध), अनुसंधान एवं शिक्षा में बदलाव के चलते तथा सूचना, ज्ञान और नीति एवं निवेश (जो कृषि उत्पादन को प्रभावित करने वाले कारक हैं) आज भी एक चुनौती बने हुए हैं। उत्पादन के परिवेश में बदलाव हमेशा ही होते आए हैं, परन्तु जिस गति से यह हो रहे हैं, वह एक चिंता का विषय है जो उपयुक्त प्रौद्योगिकी विकल्पों के आधार पर कृषि प्रणाली को और अधिक मजबूत करने की मांग करते हैं।

पिछली प्रवृत्तियों से सबक लेते हुए हम निश्चित रूप से भावी बेहतर कृषि परिदृश्य की कल्पना कर सकते हैं, जिसके लिए हमें विभिन्न तकनीकों और आकलनों के मॉडलों का उपयोग करना होगा तथा भविष्य के लिए एक ब्लूप्रिंट तैयार करना होगा। इसमें कोई संदेह नहीं है कि विज्ञान, प्रौद्योगिकी, सूचना, ज्ञान-जानकारी, सक्षम मानव संसाधन और निवेशों का बढ़ता प्रयोग भावी वृद्धि और विकास के प्रमुख निर्धारक होंगे।

इस संदर्भ में, भारतीय कृषि अनुसंधान परिषद के संस्थानों के लिए विजन-2050 की रूपरेखा तैयार की गई है। यह आशा की जाती है कि वर्तमान और उभरते परिदृश्य का बेहतर रूप से किया गया मूल्यांकन, मौजूदा नए अवसर और कृषि क्षेत्र की स्थायी वृद्धि और विकास के लिए आगामी दशकों हेतु प्रासंगिक अनुसंधान संबंधी मुद्दे तथा कार्यनीतिक फ्रेमवर्क काफी उपयोगी साबित होंगे।

(राधा मोहन सिंह)

केन्द्रीय कृषि मंत्री, भारत सरकार

Foreword

Indian Council of Agricultural Research, since inception in the year 1929, is spearheading national programmes on agricultural research, higher education and frontline extension through a network of Research Institutes, Agricultural Universities, All India Coordinated Research Projects and Krishi Vigyan Kendras to develop and demonstrate new technologies, as also to develop competent human resource for strengthening agriculture in all its dimensions, in the country. The science and technology-led development in agriculture has resulted in manifold enhancement in productivity and production of different crops and commodities to match the pace of growth in food demand.

Agricultural production environment, being a dynamic entity, has kept evolving continuously. The present phase of changes being encountered by the agricultural sector, such as reducing availability of quality water, nutrient deficiency in soils, climate change, farm energy availability, loss of biodiversity, emergence of new pest and diseases, fragmentation of farms, rural-urban migration, coupled with new IPRs and trade regulations, are some of the new challenges.

These changes impacting agriculture call for a paradigm shift in our research approach. We have to harness the potential of modern science, encourage innovations in technology generation, and provide for an enabling policy and investment support. Some of the critical areas as genomics, molecular breeding, diagnostics and vaccines, nanotechnology, secondary agriculture, farm mechanization, energy, and technology dissemination need to be given priority. Multi-disciplinary and multi-institutional research will be of paramount importance, given the fact that technology generation is increasingly getting knowledge and capital intensive. Our institutions of agricultural research and education must attain highest levels of excellence in development of technologies and competent human resource to effectively deal with the changing scenario.

Vision-2050 document of ICAR-Central Institute for Research on Cotton Technology, Mumbai has been prepared, based on a comprehensive assessment of past and present trends in factors that impact agriculture, to visualise scenario 35 years hence, towards science-led sustainable development of agriculture.

We are hopeful that in the years ahead, Vision-2050 would prove to be valuable in guiding our efforts in agricultural R&D and also for the young scientists who would shoulder the responsibility to generate farm technologies in future for food, nutrition, livelihood and environmental security of the billion plus population of the country, for all times to come.

(S. AYYAPPAN)
Secretary, Department of Agricultural Research & Education (DARE)
and Director-General, Indian Council of Agricultural Research (ICAR)
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Preface

The ICAR-Central Institute for Research on Cotton Technology (CIRCOT) is one of the premier constituent institutes of the Indian Council of Agricultural Research (ICAR), is mandated to develop new technologies and machinery by carrying out basic, applied, strategic and anticipatory research in post-harvest technology for better utilization of cotton and other fibres along with its by-products. Since its inception in 1924, CIRCOT has been offering continuous technological support to country's cotton breeding programme and provides services like training, education and consultancy to textile industry and act as a referral laboratory for textile testing. From time to time the mandate of the Institute has been fine tuned to suit the changing scenario of the cotton value-chain.

CIRCOT had drafted its first vision document "Vision 2020" in the year 2000, which was revisited with new research priorities and programmes in the year 2007 to prepare the "Perspective Plan 2025". This was followed by renewed focus and insights leading to the preparation of "Vision 2030" document in the year 2011. Through all these vision documents, CIRCOT attempted to view the changing needs of the cotton textile sector and prioritize its R&D objectives. In order to categorically position itself in the fast changing scenario of cotton processing, utilization and value addition and play a greater role in connecting the textile industry and the cotton farmers, CIRCOT has unveiled the Vision 2050 document, that integrates, encompasses and addresses all the challenges and uncertainties that may be encountered in its journey towards the year 2050 and provide the right path.

The Global demographic contour by 2050 would comprise of a population of around 9.6 billion of which India would have a population of 1.6 billion. There will be stabilization of the population in the world except for some parts of sub-Saharan Africa. The per capita land availability would shrink resulting in the pressure for land for the production of Food, Feed, Fibre and Fuel. India would emerge as a third largest economy by 2050 with an estimated GDP of $26 Trillion, next to China and USA. The population structure of India would be in favour of the working class people and with the estimated increase in the per capita GDP of around $16,250, the per capita textile consumption

and the textile demand therein are expected to grow leaps and bound.

The operating environment in which cotton based textile sector would be functioning by 2050 would be competition for the land between the food and fibre crops, resource constraint especially with respect to the water and energy which are intensively used in the sector, the significant environmental fallouts from the sector viz., GHG release, emission of toxic chemicals, effluents and other occupational hazards associated with the sector. There will be an increased purchasing power and the health and environmental consciousness among the consumers that will provide ample scope for research and development to create functionally finished textiles with specific end uses.

The human civilization by 2050 would entail a technology that would be energy conserving, water conserving and low carbon technologies. There would be need for cutting edge technologies to meet the future needs of human in varied fields such as medical, agriculture, protective, comfort and technical textiles. The significance of environment will necessitate development of Novel blended textiles of cotton with other natural fibres and provide an immense potential for bio composites. The future society will envisage the energy security through the renewable sources of biomass.

In order to resolve the dilemma in the minds "how to tackle the emerging situation" ICAR-CIRCOT is visualizing the sequence of the research and development intervention through its vision document on the path to 2050. The goals and the targets of the institute would be to ascertain mechanization of the cotton harvesting and ginning and ensuring the energy efficiency in the system, technology upgradation in trading of Indian cotton and textiles through end use based data gathering and objective data on quality and quantity of cotton to support the production and market system. The institute will inculcate the innovation in spinning and weaving technology to manufacture high quality textiles from natural fibres besides advanced application of cotton and other natural fibres in the field of technical textiles. To cater to the needs of the farmers, consumers as well as the environment, the sustainable processing of cotton textiles for varied functional applications besides emphasizing the effective and remunerative utilization of cottonseed and the plant biomass have to be addressed. The institute will also address the concern of need for new entrepreneurs and the skilled man power requirement of the industry and create centres of excellence in the field of textile finishing, cottonseed by-product utilization, automation and textile manufacturing, textile trade and market intelligence.

ICAR-CIRCOT is set for the journey to 2050 with a vision of achieving "Global Excellence in Cotton Technology" by creating a sustainable cotton processing and value addition in harmony with Human Health, Society and Environment, besides establishing itself as a textile hub for the technologies, machines, processes & products that will augment the concept of "Make in India", HRD and referral services to the South East Asian and African Countries.

Dr. P.G. Patil
Director (Acting)

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Context

The Central Institute for Research on Cotton Technology (CIRCOT) is one of the premier constituent institutes of the Indian Council of Agricultural Research (ICAR), and the only one of its kind in the world conducting R&D on the utilization of every part of the cotton plant, providing consultancy services and conducting entrepreneurship development programmes. Since its inception in 1924, CIRCOT has been offering continuous technological support to country's cotton breeding programme and providing training and testing services to the trade and industry. 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 post-harvest technology of cotton and function as referral laboratory for textile testing.

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

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 the synthetic fibre like polyester. Since the abolition of the Multi-Fibre Arrangement (MFA) and the advent of quota-free global trade in 2004, the cotton textile sector is buoyant, and exhibits tremendous growth momentum. Besides, India's progressive economic growth in recent past has resulted in increased spending on clothes dictated by fashion and comfort preferences of consumers, and is helping in expanding the domestic market as well. With the technological advances in cotton processing and value additions increasingly adopted by the global textile industry, India has emerged as a major player in cotton production, processing and value addition.

CIRCOT had drafted its first vision document "Vision 2020" in the year 2000, which was revisited with new research priorities and

programmes in the year 2007 to prepare the "Perspective Plan 2025". This was followed by renewed focus and insights leading to the preparation of "Vision 2030" document in the year 2011. Through all these vision documents, CIRCOT attempted to view the changing needs of the cotton textile sector and prioritize its R&D objectives. Formulating programmes essentially looking into the needs of the clients has been the focus of CIRCOT's research. This has resulted in the development of technologies and products that helped the Indian cotton textile industry to reach new heights. A glimpse on important milestones achieved by CIRCOT are as follows:

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 300 corporate users and is preferred over USDA calibration cotton.
c. The only technology partner in the prestigious All-India Coordinated Cotton Improvement Project (AICCIP) since its inception, guiding and aiding cotton breeders of the country in developing varieties with improved productivity and quality
d. CIRCOT's R & D in cotton ginning and skill training of workforce for ginning industry is the best in whole Indian subcontinent. Ginning Training Centre at Nagpur, with state of art facility for Research and Training, is first of its kind in Asian Continent.
e. Developed and commercialized the pre cleaning system for ginning industry under PPP mode.
f. Active participation in all components of the Govt. of India's Technology Mission of Cotton (TMC), which resulted in modernization of over 850 ginneries and clean cotton-picking practices, leading to 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 yarn 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 to achieve uniform shades through machine dyeing
l. Eco-friendly enzymatic process for textile processing
m. CIRCOT is making a steady impact by methodically foraying into cutting-edge research areas like nanotechnology, plasma processing, green composites, and technical textiles.
n. Eco-friendly process to prepare peptone from cottonseed meal
o. CIRCOT has carried out pioneering work on utilization of cotton stalks for production of pulp and paper, kraft paper for preparation of corrugated boxes and particle boards and biomethanation from textile waste by solid state fermentation.
p. Business Planning and Development (BPD) Unit with support from the National Agricultural Innovation Project (NAIP) for creating awareness, promotion and commercialization of technologies.
q. Institute has successfully executed internationally funded project under the Common Fund for Commodities (CFC), Netherlands through International Cotton Advisory Committee (ICAC), Washington and World Bank funded projects under NAIP.
r. CIRCOT has also forged research collaboration with other R&D institutions within the ICAR system as well as with other national and international research organizations and with private manufacturers. CIRCOT is also an active member of the Bureau of Indian Standards (BIS).
s. Institute has been recognized by University of Mumbai for providing education in field of textiles and basic sciences.

Thus, it is evident that the earlier vision documents have helped CIRCOT to critically focus on its R & D perspectives. The documents have also served to reset and realign strategies to achieve the Institute's vision and objectives, and serve the stakeholders with a mission spirit.

In the emerging, fast developing and dynamic technology scenario, CIRCOT ought to have a broad and clear vision for the next thirty to forty years. "Vision 2050" will 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. The main reasons which justify the need for preparation of CIRCOT "Vision 2050" and which necessitated a revisit of "Vision 2030" document are stated below.

- Increasing Urbanization and Non-Farm Rural Employment will result in shortage of labour for cotton farming operation, which will necessitate the mechanization in all spheres of cotton cultivation.

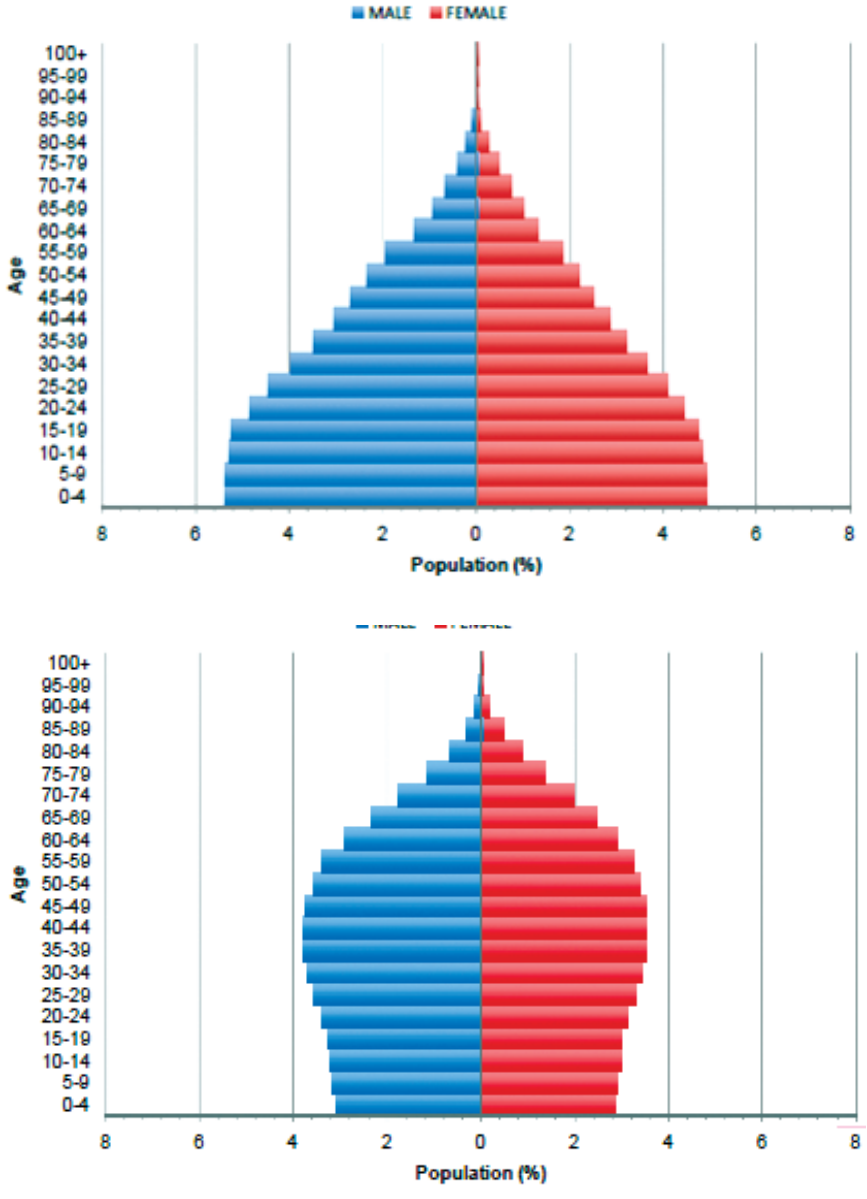
- The conversion speeds of cotton fibre into yarn and fabric are increasing with the development of technologically advanced machines which demand exceptional fibre attributes. CIRCOT's participation in All India Coordinated Cotton Improvement Project (AICCIP) needs continuous strengthening so as to assist cotton breeders to develop suitable quality of cotton commensurate with the needs of the textile industry.
- Focus on emergence of quality based marketing system and lint based marketing for the benefit of farmers to ultimate consumers. Empowering the farmers to ascertain the price of his produce according to its quality.
- Ginning is an energy intensive industry, therefore reduction in power consumption deserves utmost priority. Development of energy-efficient and ergonomically designed ginning and cleaning machinery is the need of the hour.
- Mechanical and chemical processing of textiles are energy and water intensive, resulting in GHG release, emission of toxic gases, and effluents contributing to environmental pollution and climate change. Increasing shift towards environment consciousness needs development of non-polluting, water conserving textile/cotton processing technologies.
- Use of technical textiles, i.e., textiles used for technical performance in non-conventional areas is steadily increasing. At present, the share of cotton in technical textiles is a mere 7%. Aim should be to increase it to 25% by year 2050 through novel R & D initiatives.
- Natural fibre based reinforced composites, that can substitute raw materials like wood will be the need of the future. Thus, deforestation which is a major environmental hazard can be slowed down.
- With the increase in health awareness and purchasing power, the consumers' demand for textiles is undergoing a massive shift. Demand for innovative and performance-oriented intelligent textiles is steadily increasing. The engineering and technological interventions need to be reoriented to cater the changing needs of the consumers.
- Focus on entrepreneurship development to strengthen the weak link in the supply chain viz., biomass utilization, scientific processing of seeds for oil extraction and making it suitable for edible purpose and enable the use of cottonseed meal as animal feed and for human consumption.
- Business mode for technology dissemination rather than business 'as usual' approach for transfer of technology.

In this context, CIRCOT should categorically position itself in the changing scenario of cotton processing, utilization and value addition and has a great role to play by being a bridge connecting the textile industry and the cotton farmers. The document CIRCOT Vision 2050 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 2050. The ultimate vision for 2050 is CIRCOT attaining "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 year 2050 will be opening up greater opportunities as well as innumerable challenges. India's population is expected to reach 1.6 billion mark by 2050. The necessity to feed the increasing population will create more pressure on the land availability and there will be competition for land between the food crops and the fibre crops. Beyond 2030, the competition will become stiffer for the land as it will be a source for food, fibre as well as fuel. Cotton, a commercial crop grown for its fibre, will face the major challenge from food crops for the land. Moreover, the climate change will induce a lot of uncertainty and may impact agricultural production as well. The other limiting factors that will pose a challenge in the time to come is the inadequate quantities of water and power and depletion of the fossil fuels. The technologies of the future should be socially relevant with greater concerns shown towards the environment, human health and safe disposal of waste 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 man-made 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 2050, with majority of population in the working category; the per capita income is expected to grow manifold. India will emerge as the third largest economy in the world by 2050 with an estimated GDP of $26 trillion, next only to China ($48 trillion) and USA ($37 trillion). The per capita GDP will raise to $ 16,250 (2050) as against the present per capita GDP of $ 1498. The National Household Survey 2012-13, on the Market for Textiles and Clothing conducted by the Textiles Committee, Ministry of Textiles, Government of India reveals that the all India per capita purchase of textiles was around 25.9 metres in 2012 with an urban consumption of 31.2 metres while the rural textile consumption accounted for 23.5 metres. Presently the urban population is around 31 per cent and it is expected that India's urban population will be



Age Structure of India's Population in 2010 and 2050
(*Source:* United Nations Population Division)

around 50 per cent (843 million) in 2050. With 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 textile demand at present is around 32 billion square meter with the average per capita consumption of textiles pegged at 26 metres. If we assume that the per capita consumption of textiles increase to 40 meters, the total textile demand would be 64 billion square metre. This huge demand foreseen in the textile sector will be tilted 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. Moreover, the use of cotton and other natural fibres along with their biomass will find increasing application as functional textiles (technical textiles) which will cater to diverse applications in various sectors such as automobiles, construction, agriculture, healthcare and industrial safety etc. The capability to cater to the increasing demand for technical textile products pose a major challenge.

By any stretch of imagination, 2050 will certainly present an expanding Indian cotton and textile sector. State–of–the-art post-harvest 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 capitalise 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 that requires about 450-500 man-hours/ha. Targeted cotton yield of around 1200 kg/ha by 2050 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. Mechanically harvested cotton generally has trash content above 15%, 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. Cotton plant by-products are available in plenty but are unutilized due to lack of efficient cotton stalk supply chain and non-availability of indigenous machinery for uprooting, cleaning, chipping and baling. Efficient utilisation of cotton by–products for the manufacture of value-added products is the need of the hour.

Double roller (DR) gins are of low productivity (100 kg lint/h) and consume large energy (4 units/100 kg lint). Here, the challenges are to improve DR gin's productivity and energy efficiency. Engineering interventions are necessary to reduce dust, noise, vibration and drudgery in ginning operation. The use of high productive rotary knife ginning machine needs to be explored for ginning of Indian cottons by addressing their shortcomings. The existing principles of cotton ginning should be relooked and new principles that will require minimum energy for ginning should be invented. By 2050, demand for short staple cottons will be high but the existing machines are not effective for ginning short staples and hence, offer a challenge to devise new machines. Material handling forms the major component in ginning automation and requires about 1/3rd of the total energy consumed in a modern ginnery. This is predominantly due to lack of standardization of machines and processes. For achieving efficient ginning, uniform application of moisture is required which necessitates the development of appropriate on-line moisture application methods.

Various channels exist for cotton marketing viz., farmer–ginner–consumer, farmer–trader –ginner–consumer, farmer–village merchant–commission agent–consumer. So there is a need to reduce the players involved in the market channel. This will not only empower the small farmers to negotiate for higher price, but will also usher in an era of quality-based cotton pricing system in the country. This development is expected to improve farmer's share in consumer price.

In India, cotton trade is influenced by brokers and mill representatives. The absence of labelling of cotton bales with quality parameters after ginning stage results in spinning mills being compelled to use fibres of non-homogeneous and inconsistent quality. Cotton producing countries like USA and China have established nation-wide bale tagging systems, where each bale produced from the ginnery is tagged with fibre quality data. USA has established a national database of traded cotton that provides real-time information to various stake holders like farmers, traders and industry. CIRCOT can take a lead in establishing similar database in India. There are about 350 HVI systems with private and public sectors of India, which can be pooled together and utilized for generating data for the purpose of bale tagging with quality information. If the challenging task of 100% bale tagging of Indian cottons with the fibre quality data can be achieved, it will not only ensure quality-based cotton marketing, but also bring remunerative price to the cotton farmers for their produce.

CIRCOT has been developing its own calibration cotton since 1997, which is extensively used for calibration of HVI machines. The Advanced Fibre Information System (AFIS) which is used for measurement of single fibre quality and fibre neps, does not have any standard reference material for its calibration. Hence, there is a demand from industry for supply of reference materials for calibration of AFIS. It is a real R & D challenge for CIRCOT to develop reference materials for the calibration of nep module in AFIS.

Various spinning systems like ring, rotor and vortex spinning will continue to utilize cotton for yarn production in the decades ahead. India has 48.25 million ring spinning spindles and 0.782 million rotors that contribute to the total spun yarn production of 5316 million kg (2013-14). To feed the growing requirement of yarns in textiles, new methods of yarn spinning have to be adopted. Air vortex spinning system is a new generation of yarn manufacturing technology and is capable of producing 100% cotton yarn. Thus, it can share a significant portion of the cotton spinning in the coming years. Production speeds of air jet spinning are 20-30 times higher than that of ring spinning, and 2-3 times that of rotor spinning. The air vortex spinning demands fibre with a length-to-strength ratio of at least 1.0, and a 2.5 % span length of 30 mm, with a strength of 30 to 32 g/tex to produce a quality 30s Ne yarn. This poses challenges to the breeders in developing high strength cotton varieties and for textile machinery manufacturers in perfecting the vortex machine for spinning Indian cottons.

By 2050, intelligent spinning systems with high production speeds supported by online quality-monitoring and remote access control systems are expected to be in place. The process sequence for fibre-to-yarn production will be a shorter one. The future spinning systems are expected to spin different types of fibres and their blends for development of smart and intelligent textiles. In weaving sector, achieving a weft insertion rate of 5000 m/min has become a reality with the development of multi-phase weaving. The future fabric manufacturing is expected to have advanced style change systems, robust designing capabilities, online measuring systems, integrated data monitoring systems, robotic controls and so on. The development of multifunctional warp and weft knitted fabrics and garments will be the area to be researched into by 2050.

Consumer preferences 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 has to compete with synthetics in the case of performance-

oriented garments, where the synthetic fibres/fabrics have distinct advantages.

The value of textiles can be increased manifold by textile wet processing that comprises steps such as scouring, bleaching, dyeing and finishing which involve huge quantities of water, energy and chemicals creating environmental pollution to a serious dimension. Around 290,000 tonnes of textile dyes are discharged every year globally. Waste streams generated from textile industries are hazardous and difficult to biodegrade owing to the presence of recalcitrant dyes and pigments. Development of eco-friendly, water-free processing methods adoptable by the industries is a big challenge, but a necessary pursuit. In addition, an understanding of the mechanism of biodegradability/recyclability of the effluents and "end of life thought process" is essential for environmental restoration.

The technical textile market has registered an annual growth of 11 per cent during the 11th five year plan and grow at the rate of 20 per cent during 12th plan period to garner the market size of 158,540 crores by 2016-17. Surgical cotton is a growing segment in technical textiles with a market size of Rs 57,000 crores and a growth rate of 11% per annum. The requirement of cotton for unconventional end uses like surgical cotton, mattresses, cotton swabs and tea bag threads is increasing.

The applications of high performance and functional fabrics having enhanced performance attributes and functionalities over the normal fabrics have been expanding rapidly. They are used in areas such as, protective and functional textiles, in 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 non-contact image analysis need to be developed for performance characterization. In this era of rapid globalization requiring quick and smart assessment of quality, the fabric testing concept will undergo a paradigm shift from manual to automatic testing. Devising suitable intelligent instruments for this segment of cotton textiles is another challenge for CIRCOT.

With the advancement of technology and rapid industrialization, the increased risks to human health from fire, ultraviolet rays, harmful chemicals and pesticides are mitigated through the development of protective textiles which are far from being user-friendly in terms of comfort and eco-friendliness. Development of durable and comfortable protective textiles is a great challenge for CIRCOT to work on. Textile for all climates using phase changing materials and E-textiles for

self-charging from sunlight and sensing/monitoring the physiological conditions of our body is a challenging area. Development of cellulose-based transparent fabrics 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 has to be achieved. CIRCOT can direct its research into these challenging domains to produce new generation technology/materials for mass consumption.

Nature has perfected the art of making efficient composites out of cellulose, hemicellulose and lignin since billions of years. Replicating the same for production of biobased engineered composites for high-end applications is a challenge and requires basic understanding of science and manipulation capability at nanoscale.

About 10 million tonnes of cottonseed, rich in oil, protein and essential amino acids are available in India annually. The value addition to cottonseed cake/meal by removing the toxic gossypol to make it fit for human consumption is another challenge. Energy and high end products from renewable resources is a key to ensure sustainable development. Use of cotton plant biomass for production of bio-energy, bacterial cellulose, polyhydroxy butyrate (PHB), single cell protein (SCP), poly lactic acid (PLA) and plant nutrient supplement (PNS) is a major challenging area.

Though CIRCOT is the pioneering institute in the area of cotton technology, there is a lack of vibrancy in CIRCOT's research activities and its outreach to the desired extent in the creation of trained human resource for the future cotton sector of the country. The training activities are mainly confined to evaluation of cotton quality and ginning technology and the domain of its education is restricted to Masters and Doctoral degrees in few disciplines. Coordination, guidance and involvement with the academician are essential for research activities to have multi-dimensional approach to face the upcoming challenges.

The technology commercialization is limited due to dearth of awareness among the potential entrepreneurs, both rural and urban, on the business options available on cotton based agro-products. The transfer of IPR enabled agricultural technologies through the commercial route will gain importance and recognition in the days to come. The public-private partnership mode need to be explored to have an impact and encourage participation by many stakeholders. Creation of vibrant self-sustaining Business Planning and Development unit would be a major challenge in the years to come. CIRCOT should work towards bridging these gaps.

These challenges are categorised as short term (2014-2024),

medium term (2025-2040) and long term (2041-2050). Needless to say, this description cannot account for those challenges arising out of the uncertainties which may arise and which cannot be fathomed and comprehended presently, since year 2050 is at a distant three and half decades away.

Short Term Challenges

- Reduce cost of cotton picking, transportation and handling and to mitigate labour demand through mechanisation of harvesting and material handling operations at the farm.
- Reduce trash content through on - farm cleaning of mechanically harvested cotton
- Increase the productivity of double roller gin and reducing energy consumption by half
- New ginning machine with multiple rollers.
- Customization of high capacity rotary knife roller ginning technology for Indian cottons
- Reduce dust and noise pollution in ginneries
- Establishment of cotton stalk supply chain mechanism and utilization of cotton plant biomass and ginnery waste for preparation of high value compost, bio-energy and extraction of fine chemicals
- Development of reference materials for standardisation of cotton fibre quality testing instruments, particularly the AFIS
- Engineered cotton quality through AICCIP for different end uses
- Thermal-tactile combined fabric touch tester for Indian conditions
- Improve the moisture sensitivity and poor interfacial bonding strength in natural fibre composites
- Blend cotton and other natural fibres for production of smart textiles
- Use of cotton and other natural fibres as oil spill absorbents and for flexible electronics
- Spinning of finer yarns through Air-Vortex & Rotor spinning methods
- Development of 3D woven and knitted structures for advanced composite applications.
- Development of low-cost indigenous nonwoven production machines
- Salt-free dyeing for cotton textiles
- Biomolecules for sustainable textile processing and functional finishing
- Diverse utilization of cottonseed and cotton biomass and by-products

- Strengthen infrastructure and manpower commensurate with the education and training needs of domestic and international stakeholders
- Development of innovative methods for Transfer of Technology and promotion of aggressive salesmanship
- Establishment of technology parks, business support systems like pilot plant and knowledge clusters-cum-training centres for promoting agri-business for entrepreneurs in India and abroad

Medium Term Challenges

- Minimise drudgery, handling and contamination through development of cotton harvester, cleaner-cum-module builder, cotton loader, un-loader and heaping machine suiting to the requirement of Indian farm holdings.
- Improve productivity, efficiency and ease of operation through development of high productive computer-controlled roller ginning machine
- Reworking on ginning principles to develop efficient ginning machines for all types of cotton
- Reduce the trash content in mechanically harvested cotton by developing indigenous pre and post-cleaning machinery for mechanically picked and stripped cottons
- Development of integrated machine for uprooting, cleaning, chipping and baling of cotton stalk.
- Standardize machines and processes for ginning, baling, humidification and material handling
- Developing ginning mechanism without the use of rollers and saw
- Bale press capable of producing bales weighing less than 100 kg
- National online information system for cotton fibre quality
- Cotton classification centres in major cotton producing areas
- Testing and quality assessment methods for performance characterization of smart and intelligent textiles
- Modelling and simulation to predict the mechanical and thermal behaviour of cotton textile materials
- On-line sensor-based fibre quality assessment system
- Shortening the process sequence in ring spinning and development of alternate twisting mechanism
- Development of green composites as an alternative to glass-reinforced plastics (GRP)
- Cotton wovens and nonwovens for use in filtration and medical textiles

- Water-free cotton processing technologies
- 3D printing technology in textile processing
- Conversion of cotton biomass into energy and fine chemicals
- CIRCOT to emerge as a centre of excellence in the field of education and training in cotton processing technology of international standard
- Generation of technologies in collaboration with industries and their perfection in the industrial environment, client's product enhancement and development

Long Term Challenges

- Development of high-tech computerised combined cotton harvesting, cleaning and ginning machine
- Modernisation of ginning factories in India with automated process controlled ginning machines and handling systems
- Artificial intelligence-based visual single-index grading system for judging cotton quality
- Develop methods to engineer the properties of cotton amenable for use in technical textiles
- Universal spinning machines for processing of all natural fibres
- Development of indigenous high speed shuttleless weaving machines
- Development of multifunctional cotton-based smart textile materials
- Dye-free colouration of cotton textiles
- CIRCOT to establish itself as a deemed university for courses in cotton and allied fibre technology sector catering to both the national and international students
- Emergence of India as global hub for supply of technology and machinery for cotton processing and by-products utilisation

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Operating Environment

Indian Cotton Scenario

Cotton is an important commercial crop cultivated in India. It is grown in an area of around 11.7 million hectares (ha) in 2013-14, accounting for about 30 percent of global area under cotton and 18 percent of world cotton production. With increased acreage and advent of Bt-technology, the cotton production in the country in the season 2013-14 had been estimated at 39.0 million bales (1 bale=170kg). Cotton plays a major role in sustaining the livelihood of an estimated 5.8 million cotton farmers. In India, cotton is grown in three diverse agro-ecological zones viz., Northern zone which includes Punjab, Haryana and Rajasthan, Central zone comprising of Maharashtra, Madhya Pradesh and Gujarat, and Southern Zone comprising Andhra Pradesh, Karnataka, Tamil Nadu and Telangana. In the recent period cotton is gaining momentum in non-traditional areas such as Orissa, West Bengal and Tripura.

Cotton productivity in India, despite phenomenal increase in recent years to around 594 kg/ha, is still lower than the world average of 775 Kg/ha and the productivity in countries like USA (735 Kg/ha), China (879 Kg/ha), Australia (1270 Kg/ha) and Israel (1700 Kg/ha). In India, the agro-climatic condition are suitable for all the four cotton species. At present Bt cotton hybrids cover 95 per cent of cotton cultivated in India, however only a few of them meet the needs of the modern high-speed spinning and weaving systems like high strength, high extensibility, high maturity and low variability. Moreover, Indian cotton is rather trashy because of improper handling of the raw material at the farm and ginning level. This has remained a major concern for Indian cotton.

World Cotton Scenario

Cotton is one of the most widely cultivated cash crops across the world and an important natural fibre, accounting for around 40 percent of the total global fibre consumption. The area under cotton cultivation across the world in 2013-14 was about 33.1 million hectares. Since productivity has levelled off in most of the leading countries, the total production of cotton in the world as a whole remains at about 24.9 million tonnes of fibres.

The major players in cotton production and trade include China, India, USA, the EU and Central Asian and African states. More than three-fourths of cotton is accounted for by developing countries and around one-third of total cotton produced is traded internationally. Developed countries account for most of the increase in the consumption of end-use products of cotton through import of clothing and textiles from developing countries. Mill consumption and imports of raw cotton are increasing in developing countries, particularly in industrialised Asian countries. The trade in raw cotton is mainly from developed countries to developing countries, but recently trade among developing countries is also growing. Benin, Burkina Faso, Chad and Mali, known as the 'Cotton 4' countries, are the major cotton producing countries in western Africa besides Egypt, Sudan, Zimbabwe and Tanzania. Among the Asian countries, next to China, India is playing an important role in the global cotton and textile markets.

Textile Industry

India's textiles and clothing industry is one of the prime movers of our national economy, contributing to 4 percent of the GDP, 14 percent of the industrial production and employing about 35 million people. It is also one of the largest contributing sectors of India's export accounting for nearly 12 percent of the total export earnings. The textile sector is the second largest provider of employment after agriculture. Thus, the growth and development of the textile industry has a direct bearing on the economy of the nation.

With the emergence of quota-free trade regime and possibility of the textile manufacturing base shifting to Asia, the Indian textile and clothing industry is in a resurgent mood. India has already been recognized and regarded as the major beneficiary of the free trade regime. The situation is slowly posing new challenges to the Indian textile industry. A free trade regime has also enabled the consumer to choose the best from among the diverse product and services available in the world. Therefore, India is facing steep challenges from countries like China and other Asian nations, already known to produce cheaper textiles, and market the same.

The Indian textile industry consumes fibres and yarns of various types, of which cotton has a major share. Cotton accounts for more than 75 percent of the total fibre consumption in the spinning mills and around 54 percent of the total fibre consumption in the textile sector. This makes cotton the primary raw material for the textile industry. The consumption of cotton has significantly increased over the years with

rapidly expanding domestic textile industry. The spinning industry, has recorded phenomenal growth in the last two decades in terms of installed spindles and yarn production. The pace of modernization received a boost with the launch of "Technology Up-gradation Fund Scheme" (TUFS) by the Government of India in April, 1999. This growth in the spinning industry has led to continued rise in cotton consumption.

Although domestic demand accounts for a major part of cotton produced in India, textiles and clothing exports are outpacing the domestic demand, and emerging as an important determinant of overall cotton and fibre demand in India. Government policy interventions that influence raw material and product prices, industry structure and technology significantly affect both the growth in domestic demand for cotton and the global cotton trade. However, the cotton trade is largely distorted because of the subsidies in developed countries that depress global prices and affect the livelihood of millions in the developing countries.

Price Trend and Volatility

India's cotton economy revolves around the producers, who will continue with cotton production as long as it is remunerative. It is necessary to ensure higher productivity at a lower input cost without compromising on fibre quality, so that cotton cultivation remain remunerative to the farmers. The volatility of the cotton price in the global market is a major concern for Indian textile industry. The highest price volatility in cotton in the past few years followed by a collapse in April, 2011, had immediate reactions in the domestic market. The market has showed an improvement since then, which is evidenced from the increase in the cotton yarn production by 10 percent and fabric production by 5 percent during 2013-14 over the previous year. Though an upward trend is observed there is a deceleration in the growth rate of production of Cotton Yarn and Fabric with respect to 2012-13. Price trend and volatility will govern the cotton economy in the years to come.

Policy Issues

Indian Government has intervened from time to time to boost up the competitiveness of the Indian textile industry in the global market. The modernization and development of textiles and clothing industry are being pursued by the Government of India through various Plan Schemes, namely, Technology Up-gradation Fund Scheme (TUFS), Integrated Skill Development Scheme (ISDS), Technology Mission on

Cotton (TMC), Technology Mission on Technical Textiles (TMTT), Integrated Scheme for Powerloom Sector Development, Knitwear Technology Mission as well as Schemes for Development of Handloom and Handicraft Clusters. Through these schemes, the Government proposes to increase the investment in the textile sector to create more employment.

Though there is no recognizable impact yet on the global economic slowdown on Indian textiles and clothing industry and exports to various countries, the government has introduced several provisions in the Foreign Trade Policy 2009-14, further supplemented in August 2010, for providing incentives to the textile and clothing exports. This includes incentives for exports to focus on markets and products, interest subvention on pre-shipment credit, duty-free import of trimmings etc. required by the garmenting industry and duty-free import of tools by the handicrafts industry. This apart, financial assistance is being provided to the exporters under the Market Development Assistance Scheme and the Market Access Initiative Scheme, for enhancing market share in existing markets and for exploring new ones. The political factors may continue to remain conducive for development of textile and clothing sector in the coming years. But better emphasis needs to be given for efficient use of available resources, modernization of technology, environmental sustainability in harvest and post-harvest operations and energy conservation.

Environmental Issues

Environmental considerations in agriculture production have assumed greater emphasis in recent years. Moderation in the use of fertilizers and pesticides has been suggested from time to time, but there has been very little impact. Environmentally conscious countries in Europe and America seem to prefer what has been euphemistically called “organic” cotton, grown without the use of objectionable inputs. The development of “colour cotton” or naturally tinted cotton has assumed significance at a time when the use of harmful dyes is questioned by some countries in the west.

Climate change is one of the main challenges facing our society today. Industries, scientists, politicians and society are called on to halt the rising emission of greenhouse gases and make more efficient use of existing resources. Cotton industry is one of the largest industries of the world and its impact on greenhouse gas emission and climate change is significant. However, the measurement of carbon footprint of textile value chain is ambiguous because of its complex nature and

hence, needs reliable research.

The major environmental issues in the cotton textile sector are: high-energy consumption, use of toxic chemicals, chemical discharge creating water pollution and generation of solid waste. The textile sector is being constantly condemned as one of the world's worst offenders of pollution norms. As many as 2,000 different chemicals are used in the textile industry, from dyes to transfer agents. Water, which is a finite and quickly depleting resource, is used at every step of the processing both to convey and fix chemicals on to the textile substrates, and to wash the excess chemicals into the discharge. The water full of chemical additives is then expelled as waste.

The major occupational hazards in the cotton sector are attributable to the use of unsafe chemicals, generation of fibre dust, vibration and noise, and monotonous repetitive processes. The major problems associated with dust are respiratory problems that include byssinosis, bronchitis and bronchial asthma. The problems are highly prevalent in mills of developing countries like India. Noise-induced deafness, occupational skin diseases and respiratory disorders were found to be some of the common ailments in textile clusters. Increasing incidence of cardiac failure among workers owing to inhaling of gases/smoke containing carbon disulphide for prolonged periods too is a major cause for concern. More efforts could be directed at providing an environment conducive to the general worker's health.

Strengths, Weaknesses and Threats

The Institute has a well-established state-of-the-art facility for ginning located at the Ginning Training Centre at Nagpur and laboratories with sophisticated equipment in the field of Mechanical Processing and Chemical Processing of the cotton textiles at its headquarters in Mumbai. CIRCOT has established its prominence in the textile sector by attaining status of a Referral Laboratory for textile testing. The Institute is also accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL). It has well qualified and trained scientific and technical staff. The Institute has emerged as a Nodal Agency for developing certified reference materials for cotton and its allied products for calibration of the instruments used in textile testing. CIRCOT serves as the connecting link between the cotton producer on one hand and the trade & textile industry on the other for bettering the cotton based textile sector. Trade and industry look upon this Institute as the primary agency for promoting Indian cotton across the globe. With the induction of the Zonal Technology Management and Business

Planning Development (ZTM BPD) unit at CIRCOT, Mumbai, the commercialization wing and the transfer of technology activities have gained new impetus.

The octogenarian institute is now faced with the drain of experienced scientific and technical personnel on account of superannuation and retirements. Replacement of human resource is not taking place as desired. Depleting scientific staff strength is becoming a constraint. Despite its potential to excel in the realm of research, the Institute is unable to do so for want of physical space for the expansion of its laboratories. The Institute lacks international exposure, and interaction with the textile industry is not to the desired extent.

Though cotton has its unique quality characteristics for wear comfort, it is likely to face formidable challenge from synthetic fibres in which researchers are attempting to infuse cotton-like qualities. Success in these researches may threaten the use of naturally grown cotton fibre. Many of the industry-supported research associations are shifting their research focus over to man-made fibres. This shift is a potential threat to the growth of cotton textile industry in the country. There is need to strengthen research efforts in the realm of cotton, such that the desirable qualities of synthetics are built into it whereby cotton retains its edge over competing fibres.

New Opportunities

Research and development should foresee the scenario likely to emerge in future that will primarily be of depletion of natural resources. Therefore, opportunity exists for developing technologies and methodologies that can produce quality yarn and fabric while at the same time conserving energy and establishing a low carbon society by 2050. Besides, the emergence of quota-free trade regime has widened the scope for marketing Indian textiles. This scenario presents CIRCOT an opportunity to develop quality cotton and create avenues for greater use of Indian cotton in the world market.

Knowledge and experience gained in the past provides opportunities for the future. The celebrated hand-woven fine Dacca Muslin has not so far been emulated in fabric production by the use of modern machines. The challenge is to produce similar fine textile from cotton on high speed machines. To achieve this, the production of yarns which contains less number of fibres in the yarn cross-section can be envisaged by developing future generation spinning machines.

Immense opportunities exist in the production of novel blends using cotton. Though good blending of cotton with synthetic fibres has been achieved, there is a gap in the development of blends of cotton with other natural fibres. This is primarily due to the non-realization of the perfect blending index. Opportunities exists for engineering the properties of natural fibres like jute, ramie, acacia, hemp, kenaf by methods such as degumming, softening etc., to make them pliable and compatible with cotton. This can enable the development of 100% natural fibre blended yarns, the use of which is manifold, especially in home and technical textiles. Such developments will aid in maximum utilization of the lesser-exploited natural fibres such as ramie, jute, acacia and kenaf which are abundantly grown in the South Asian regions. The extensive and economical use of natural fibres will lead to increased plantation that will aid in carbon sequestration.

Opportunities also exist for development of indigenous machinery for harvesting of cotton particularly short staple varieties from densely populated fields as well as for ginning such cottons. Development of indigenous technologies for the testing of fabric used in tropical Indian weather, woven/nonwoven fabric from short staple varieties and blends of cotton with natural fibres are other areas in which CIRCOT can

play an active role. Cheaper and more accurate test methods for fabric evaluation may be devised specially for tests like fabric handle which are now done subjectively. New methods of fabric development from natural fibre blends have to be created for application in technical textiles. Interventions in the DREF-Friction Spinning, air-jet spinning, vortex spinning, wet spinning, electro spinning as well as in conventional yet dominant ring spinning technology to add value to Indian cotton and natural fibre blends are areas in which CIRCOT can actively work.

Processing sector demands continuous modernization, particularly in spinning sector by adopting new methods like friction and air-jet spinning, and in weaving – 3D fabric. These methods will invariably lead to new application areas such as technical textiles and natural fibre composites. Specific and desired value-additions can be achieved by cutting-edge research interventions like plasma treatment, supercritical carbon dioxide processing and nanotechnology. Finally, having interaction with consumers regarding their preferences and direct marketing will complete CIRCOT's driving role in the value chain.

India is emerging as a significant player in technical textiles with an annual growth rate of 14%. The current per capita consumption of nonwovens in India is less than 100 g. The opportunity for cotton and other natural fibres exists in filtration textiles, agrotextiles, sports textiles, geotextiles, protective textiles, medical textiles and smart textiles. Natural fibres have the advantages over commonly used synthetic fibres like glass and carbon because of their lower density, good specific strength, biodegradability, non-hazardous nature, ease of processing, abundant availability, recyclability and cost-effectiveness. The depletion of petroleum resources coupled with awareness of global environmental issues has generated the need for new green materials independent of petroleum based resources. The development of completely biodegradable composite materials using bio-polymers has a great scope in future. Enormous opportunities exist for the use of short staple desi varieties in the field of technical textiles, especially in medical textiles for use like in wipes, diapers and hygiene pads as well as for production of woven and nonwoven fabric for which niche market exists worldwide. Geographically, Indian soil condition is most suited for the cultivation of good quality short staple cottons.

CIRCOT can etch its own path in the use of nanotechnology and plasma technology to develop smart textiles such as scaffoldings, implants and antimicrobial coatings to be used in medical textiles and also for high end filters. Yet another field for CIRCOT to explore and innovate is in Biomimicry. Interesting and exciting opportunities exists for

developing textiles mimicking the defensive and supportive mechanisms that exists in nature, for the future needs of human beings. Biomimicry can be achieved by developing innovative textiles via manufacturing routes of apparels, composites, specialized body wear and equipment. Biodegradable composite materials will be the necessity for a low carbon society. Towards such an effort, a multi-agency approach involving the industry, Government, academia, research laboratory, certification/ standardization and user agencies would be required for a complete shift to textile-based composite technology.

Immense opportunities exist for CIRCOT in the utilization of the abundant biomass generated from cotton for power generation. Opportunity exists to improve the energy security by reducing dependence on non-renewable resources. The setting up of biomass power plants and process for biomass power generation can be further evolved and optimized. The use of bio-based renewable resources also holds great potential for industrial application in many sectors including energy, organic chemicals, polymers, fabrics and health-care products. Further, the utilization of by-products of cotton plant for high value end products have not been fully exploited, providing another cutting-edge for the Institute to carry out its research and development. The research on environment friendly processing and dyeing technologies should be strengthened. Development of new processes and refinement of nascent water saving technologies, such as plasma and supercritical carbon dioxide in textile processing, which will drastically reduce the water requirement and the pollution load should be evolved and established.

Another major opportunity for the Institute is in training and consultancy in all the fields of post-harvest processing for the global community. Special focus for training and consultancy to the developing nations where cotton production is showing an upward trend can be given. Besides, capacity building and entrepreneurship development in all spheres of cotton sector is an immense opportunity.

CIRCOT is poised to have a tremendous impact globally, in the post- harvest processing scenario by 2050. The opportunities envisioned will require the creation of new innovative business sectors and entrepreneurial skills. 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 develop agricultural practices for a prosperous and sustainable economy benefitting the farming community, besides ensuring environmental stability and sustainability. The benefits on the

environmental and social fronts will be reduction of greenhouse gas emissions, improving human and animal health by reducing exposure to harmful substances by use of natural bio-based materials instead of chemical and synthetic materials, job creation and rural development. ❑

Goals and Targets

The foregone chapters have documented the need for preparation of Vision 2050, described the operating environment of the cotton value chain and related technologies, and outlined the future challenges for the next 35 years, which need to be addressed by the cotton technology sector, in general, and CIRCOT in particular so that the Institute's R&D activities can be planned to ensure and fruitful results and benefits to the stakeholders.

The goals and targets for CIRCOT's Vision 2050 document are as follows:

1. **Mechanisation of cotton harvesting and Ginning**
   - Mechanical cotton picker/stripper suitable for small farm holdings
   - Combined cotton harvesting, cleaning and ginning machine
   - Integrated machine for uprooting, cleaning, chipping and baling of cotton stalk
   - Standardization of Machine Parameters, Ergonomics and Development of Specification in compliance with international standards
2. **Development of innovative technologies for cotton ginning**
   - Reworking on innovative ginning principles to develop computer-controlled high production and energy-efficient ginning machine for all types of cotton
   - 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
3. **Technological up-gradation in trade 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 AICCIP for different end uses
   - Artificial Intelligence-based visual grading system for judging cotton quality
   - Simulation and modelling of Textile Structures

4. **Innovation in spinning and weaving to manufacture high quality textiles**
   - Cotton-rich smart textiles for application in communication, protection and health care
   - Universal spinning machines for the processing of all natural fibres
   - Development of 3-dimensional fabrics and shaped garments by weaving

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 applications
   - Transparent cotton textiles and papers
   - Atmospheric moisture trapping fabrics
   - Development of high performance green composites as an alternative to glass reinforced plastics (GRP)
   - Development of 3D woven and knitted structures for advanced composite applications
   - Development of indigenous needle punching machine for nonwoven production

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 by supercritical carbon dioxide and plasma technologies.
   - Synthesis of safe chemical dyes and exploitation of vegetable dyes.
   - Novel biomolecules for processing and finishing of cotton textiles
   - Development of 3D printing technology for textile finishing
   - Nano-scale architecture in cotton textiles to impart dye-free colouration
   - Development of comfortable light weight smart textiles to monitor physiological conditions of health
   - Eco-friendly method for regeneration of cellulose
   - Development of breathable protective textiles
   - Novel functional finishes to cotton and blended textiles through nano-, bio-, chemical and plasma technologies

- Development of energy-efficient eco-friendly effluent treatment methods by chemical and biological techniques
- High performance fabrics/garments to address the problems of climate change

7. **Effective and remunerative utilisation of cottonseed and plant biomass**
   - Energy efficient machinery for cottonseed processing and utilization of linters, hulls, deoiled cake for value added products.
   - Commercial Utilization of cotton stalks
   - 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.
   - Gossypol-free cottonseed cake for animal and human consumption
   - Fractionation technology for cotton biomass to obtain high value compounds
   - Production of ethanol, hydrogen and furfural from cotton biomass
   - Off- farm engineered cellulose from microorganisms
   - New millennium Engineered fibres from natural sources
   - High value compost and bio-energy from cotton plant biomass
8. **Development of human resource 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
   - Establish centre of excellence in textile finishing, cottonseed & by-product utilization, automation & textile manufacturing and advanced centre for textile trade and market intelligence across the country
   - Expansion of the Institute in New Campus 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 exposures to in-house trainers
   - Innovations in Entrepreneurship Development Programme (EDP) for commercialization of CIRCOT technologies

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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 have resulted in the development of machines and generation of technologies which have addressed the concerns of efficiency, economy and the environment in the past 90 years. Over the years, India has emerged as the second largest producer of cotton (with potential to become number one in cotton production in coming years), which is the primary raw material for the textile industry. The improvement achieved in productivity has augmented the domestic cotton supply to meet the fibre needs of the domestic mill sector besides providing sufficient quantity for export. This has largely reduced the dependence of the domestic mills on imported cotton. Novel technologies researched and established by CIRCOT have also helped to promote the use of Indian cottons in textile applications, either alone or in blends with polyester and other natural fibres for various end-uses.

'Sustainability' is the mantra of all future human endeavours. Keeping sustainability in view, in the coming years India should aim at becoming the first not only in production and export of cotton, but also in developing appropriate technologies and value-added products. Needless to say, CIRCOT intends to play a major role in this evolving scenario. CIRCOT views to harness its potential of brain, brawn and attitude to move forward and seam itself with the fast changing scenario on cotton technology and vigorously pursue and establish itself in challenging areas. Accordingly, the programmes initiated in CIRCOT need to emphasise on newer areas of application, such as agrotextiles, technical textiles, medical and health care, smart and intelligent textiles, all made from cotton and other natural fibres, such that the demand for cotton would remain on a crest at all times. This will ensure that the primary objective of the Indian cotton farmer getting competitive price on a sustainable basis is also achieved. Additional income to the cotton farmers would also to be ensured through effective utilisation of cotton stalk for the manufacture of value-added by-products. The research

activities of the Institute in the coming decades would significantly focus on generation of technologies and processes for a green earth. The linkage of the Institute with farmers and the textile industries would undergo a sea change with the adoption of a new business development model for its technology transfer activities, with special emphasis on rural employment generation and augmentation of farm income.

In its way forward towards 2050 or another ninety more years, CIRCOT desires to achieve one milestone every year. The challenging but exciting field of cotton technology offers enough opportunities to do so, integrating the interests of all stake-holders in its value chain, right from the farmer to the consumer. The goal will always be on building up CIRCOT as a self-sustained institution of international repute with the vision of "Global Excellence in Cotton Technology" by creating a sustainable cotton processing and value addition in harmony with Human Health, Society and Environment, besides establishing itself as a textile hub for the technologies, machines, processes & products that will augment the concept of "Make in India", HRD and referral services to the South East Asian and African Countries.

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Laser typeset at M/s Print-O-World, 2568, Shadipur, New Delhi 110008 and printed at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase-I, New Delhi 110 028.