#Future

Kerala's Emerging Technology Hub, Thiruvananthapuram

Strategy and impact report

Kerala Startup Mission

Research Partner: Grant Thornton

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Contents

Executive Summary

Kerala stands at a pivotal moment in the evolution of its technology industry, where the key drivers of value creation are shifting **towards computation, intellectual property, and talent in the Knowledge Economy**. According to the World Economic Forum, the job market will undergo significant transformation in the coming decade, with 83 million current jobs being displaced and **69 million new roles being created**. To harness this transformative shift, there is an urgent need to shape an **innovation ecosystem where Kerala's startups thrive at the intersection of emerging technologies and sectors** in which the state holds a distinct competitive advantage.

Investing in innovation clusters and startups is inherently risky, and success will only follow if the government creates a robust facilitation environment to support ecosystem growth. India has seen similar developments in recent years, where ecosystems centred around initiatives like UPI, Aadhar Stack, and ONDC.

The **Emerging Technology Hub (EMTH),** spearheaded by the **Kerala Startup Mission and the Government of Kerala**, represents a focussed effort to **build innovation clusters around select technologies and sectors**. This initiative aims to nurture cutting-edge startups and position Kerala as a global leader in the tech industry. This report outlines the EMTH concept and its key components, including market analyses of various emerging technologies and sectors, an operational framework, governance structure, and the implementation plan.

The **focus sectors** identified for **EMTH** include **Space, Digital Media & Entertainment, Healthcare & Lifesciences, Food & Agriculture, and Energy**.

Each sector presents promising use cases that can position Kerala as an innovation leader: **Celestial Connect** in Ground Station as a Service, **Orbital Nexus Labs** in satellite communications, and **GeoVision AI** for spatial data applications in urban planning and conservation. In Digital Media & Entertainment, **VirtuEd** leads in immersive AR/VR training, **StoryScape** pioneers' interactive movies, and **KeralaVerse** reimagines tourism in the Metaverse. In Healthcare, **HealthShield** advances AI diagnostics, **GenomeGuard** enhances early disease detection, and **MediLink** enables telepresence surgery. The Food & Agro sector features **AgriGenome** for agri-genomics, **HarvestMind** for AI agriculture, and **FarmTech Stack** for crop-specific solutions. Finally, **PowerSphere** supports local energy communities, **EcoOptimize** drives energy efficiency, and **H2 Horizons** fosters the hydrogen economy in the Energy sector.

The project has a proposed capital outlay of approximately ₹260 crore over a three-to-four-year timeline, with an anticipated internal rate of return (IRR) of 10-11% over a 25-year period. These financial estimates are tentative and will be refined as the financing model and engineering designs are finalised. EMTH will be established as a non-profit entity, strategically designed to house one or more for-profit entities within its framework.

The **Tech Advancement Centres (TAC),** which operate under EMTH, will focus on **market-making programs** independent of the infrastructure development timeline. Once these programs mature, **TAC portfolios will be converted into Investment Vehicles (IVs)** based on investor interest. These programs will target **global markets, not just Kerala**.

All infrastructure financed through government support, CSR grants, or other non-profit channels will be housed within EMTH's non-profit entity.

Thus, **EMTH** is envisioned as an **integrated ecosystem designed to foster collaboration, accelerate commercialization,** and **provide critical support for technological advancements**. Its key features include:

- A cohesive environment fostering innovation in selected sectors and emerging technologies.
- Digital infrastructure and pathways for commercialization.
- State-of-the-art physical infrastructure tailored for testing and validation.
- Sector-specific strategic partnerships, market-making programs, and sandbox environments to encourage experimentation and growth.

Technological business models evolve due to three primary triggers.

1. Rapid technological breakthroughs, such as advances in computing or materials science, which give rise to new industries. EMTH will not focus on this trigger.
2. The **convergence of gradual technological improvements**, such as industry cloud platforms and IoT, which require facilitation to develop markets and innovation clusters – **this will be EMTH's core focus.**
3. **Changes in regulations or policies**, like those governing Ethical AI or Central Bank Digital Currency, **which may eventually require EMTH's support**. However, the initial focus will remain limited due to the fewer instances of such developments in the local ecosystem.

This report also outlines the roadmap and implementation strategy required to achieve the EMTH's objectives.

1.

Introduction

Emerging technologies hold immense potential to reshape industries, economies, and societies. Recent advancements in artificial intelligence (AI), such as deep learning, generative AI etc, are poised to revolutionize all sectors. According to global studies and initiatives led by organizations such as World Economic Forum, these technologies are key drivers of future innovation and economic growth. Strategic investments in emerging technologies are essential for unlocking their full potential. In this context, it is essential for Kerala Startup Ecosystem to strategize what it needs to do to take full advantage of this paradigm shift. Emerging Technology Hub Project in conceptualized in this context.

Methodology

Analysis and Identification of Emerging Technologies: The study commences with an in-depth analysis of technology-based business models and the identification of 100+ emerging technologies. This phase integrates findings from multiple studies to pinpoint technologies poised to make significant impacts across sectors.

- **Assessment of emerging technologies:** Each identified technology undergoes an assessment to evaluate its potential applications within Kerala's innovation ecosystem. Factors considered include technological relevance, potential economic and societal impacts, and alignment with regional developmental goals.
- **Sector assessment within Kerala's innovation ecosystem:** An assessment is conducted across 13 sectors to determine their readiness and suitability for adopting emerging technologies. This assessment utilizes 9 parameters and scoring criteria to identify 13 sectors that exhibit strong potential for disruption in EMTH context.
- **Selection of top sectors (verticals):** Based on weighted scoring from the sector assessment, the top 5 sectors are identified. These sectors demonstrate the highest potential for leveraging emerging technologies effectively within Kerala's unique socio-economic landscape.
- **Evaluation of emerging technologies (horizontals):** Within each of the 13 identified sectors, an evaluation of focus technologies is conducted. Technologies evolve in two distinct modes, characterized by Technology Readiness Levels (TRL) and Business Maturity Levels, crucial benchmarks in evaluating their applicability and readiness for integration. This assessment explores various emerging technologies, their relevant use cases in order to ascertain the optimal portfolio of emerging technologies – "horizontals" under EMTH. These will serve as the cornerstone "Technology Advancement Centres" or TACs, propelling the engine of EMTH forward.
- **Tech and sector interlock matrix:** A matrix is developed to align technological capabilities (Horizontals) with sector-specific requirements (Verticals). This matrix facilitates the prioritization of sectors best suited for the establishment of the EMTH, ensuring strategic alignment and synergy between technologies and sectors.
- **Financial assessment:** The financial assessment is undertaken to determine the feasibility and financial requirements for establishing the EMTH. This assessment encompasses initial setup costs, operational expenses, and potential revenue streams to ensure sustainable implementation.
- **Finalization of EMTH components:** Based on the findings and assessments, the components of the EMTH are finalized. This includes defining the necessary physical infrastructure, establishing operational frameworks, and structuring governance models to support effective management and oversight of the hub.

This methodological framework aims to systematically integrate emerging technologies into Kerala's innovation ecosystem, fostering sustainable development, economic resilience, and technological advancement across the region.

2.
Technology Landscape

Global tech innovation landscape

In the rapidly evolving global landscape of technology, it has become imperative for regions to position themselves strategically to harness emerging opportunities and innovations. The global tech landscape is characterized by unprecedented innovation, transformative technologies, and dynamic shifts across Industries. Emerging technologies are reshaping traditional business models and creating new paradigms. Understanding the global tech dynamics is key to identifying areas of growth, collaboration, and competitive advantage for EMTH. A summary of some of the key tech dynamics is outlined below.

Key Dynamics	International	National
Regulation and Govt Policy Focus	US CHIPS Act (USD279 Billion into semiconductor research and related field), Regulations on AI, Push for local eco-systems, GDPR	Credit on Unified Payments Interface (UPI), Open Network for Digital Commerce (ONDC), Cyber Security, PDP law
Technology Advances	Generative AI, Homomorphic Encryption (AI on encrypted data), Metaverse, Artificial Superintelligence (ASI), 5G and 6G, Chip and material science level innovations	5G and Innovations, UPI Lite
Industry Trends	Industry Cloud Solutions, Adaptive AI in domain specific problems, Zero-trust models, multi-cloud, cross-industry platforms, sustainability	Scaling towards larger customer base, language computing
End-user Trends	Bridging Physical and Digital World	Social Commerce, Convenience, Quick Commerce, Need for entertainment

Table 1. Key tech dynamics

From the proliferation of artificial intelligence and the Internet of Things to the emergence of quantum computing and blockchain technology, the latest advancements in technology globally are set to revolutionize how we live, work, and interact with each other.

According to a study by the World Economic Forum (WEF), the job market is poised for significant changes by 2027. While 69 million new jobs are expected to be created globally, there is a forecasted elimination of 83 million existing jobs due to the widespread adoption of technology and the introduction of new business models. Historically, the successful regions in such job disruptions were places in which a cluster of firms got established by chance or design. Silicon Valley in a prime example of the same.

From a strategic planning perspective, it is imperative that countries create innovation clusters focussed on emerging technologies cutting across different sectors to become successful in this massive disruption in job market. Innovation clusters create new startups, which graduate into larger corporations, create a fertile ecosystem for research and above all upskill the employment base and make them fit for jobs of tomorrow.

India's tech innovation landscape

India's digital revolution has opened unprecedented opportunities for startups, facilitated by widespread smartphone adoption, affordable internet access, and the rise of digital payment platforms. The focused efforts at promoting innovation and entrepreneurship will ensure an extraordinary wave of long-deserved growth and prosperity that can serve the interests of the rest of the world as well as India, by creating a nation of job-creators vital for sustainable growth. The transition of Indian tech services from mere outsourcing destinations to valued business partners for global firms has solidified India's position as a powerhouse in tech services worldwide.

Dynamic talent & market landscape

1. **Youthful Workforce:** Over 65% under 35 (World Bank, 2023)
2. **Engineering Powerhouse:** 1.5 million graduates annually (PRS India)
3. **Affordable Expertise:** Average software developer salary $6,500/year (Glassdoor, 2023)
4. **Surging Connectivity:** 749 million internet users, 12.5% increase in users from last year (Statista, 2024)

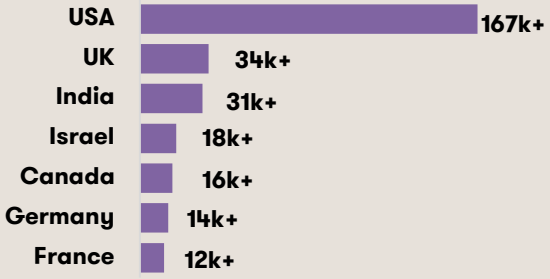
Startup growth and government initiatives

1. **61,000** recognized startups as of 2023 (DPIIT, 2024)
2. **4,500** new startups in January-March 2024 quarter (DPIIT, 2024)
3. **442** startups in 2016 **vs. 120,000+** today (NASSCOM)
4. **$350 billion** combined valuation of 113 unicorns as of January 2024

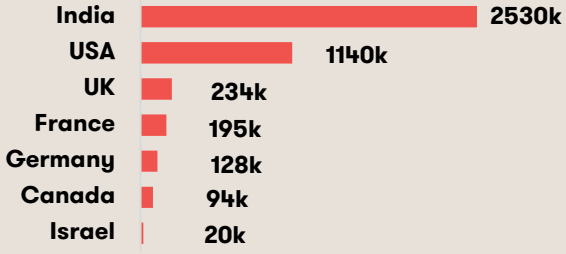
Investment and DeepTech focus

1. **$15 billion** raised by Indian startups in 2023 (Tracxn)
2. **54% increase** in funding from the previous year (Tracxn)
3. **15x** growth in the number of tech startups over the last decade
4. **14%** of total cumulative funding in the past five years secured by DeepTech startups.

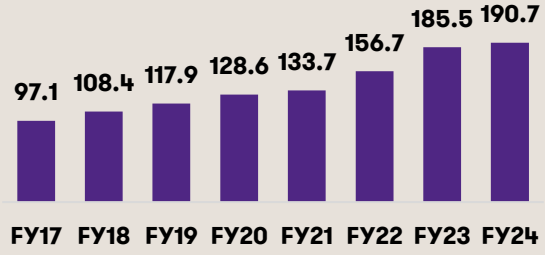
Leading tech startup ecosystems in the world in 2023 (number of startups)



Science, Technology, Engineering and Mathematics (STEM) graduates in 2022



India's rising tech-services export (US$ billion)



Source: RBI, NASSCOM, IBEF, PIB, DPIIT, Glassdoor, World Bank, Startup India, Tracxn, CII, Media reports

Regional tech innovation landscape

In the dynamic landscape of regional technology innovation, Kerala stands out as a hub of pioneering home-grown firms and startups. From cutting-edge software solutions to high-value manufacturing innovations, Kerala's ecosystem thrives on deep-tech and B2B ventures. Supported by initiatives fostering entrepreneurship and a robust network of venture capital, Kerala's tech scene is not only growing but also diversifying into niche-sectors, promising a fertile ground for innovation and economic advancement. As Kerala embraces its role as a catalyst for innovation in South Asia, its journey underscores the power of local ingenuity and global ambition converging to shape the future of technology and entrepreneurship in the region.

Diverse innovation landscape

1. **Software Pioneers:** IBS, SunTec, VisualIQ.
2. **High-Value Manufacturing:** Navalt (solar boats), Terumo Penpol (medical equipment), Gen-Robotics.
3. **Emerging Sectors:** B2B SAAS (BuildNext, Carestack), deep tech (Zaara Biotech, Inntot, Hex20.Space, EyeRov, Cavli Wireless).

Startup ecosystem dynamics

1. **Funding and Recognition:** $33M raised in 2023, Unicorn emergence (Open Money).
2. **Government Support:** Kerala Startup Mission, IEDCs facilitating innovation culture.
3. **Returnee Entrepreneurs:** Professionals returning to start ventures, establish subsidiaries.

Corporate engagement and investment

1. **Corporate Initiatives:** Allianz Technologies, US Technologies strengthening local startup connections.
2. **Venture Capital Ecosystem:** Fund of funds scheme, early-stage funding robustness.
3. **Growth Opportunities:** Need for Series A and later-stage funding, sector-specific investment focus.

30K+
Number of aspiring entrepreneurs

6000+
Startups

190
Deal count

$725 mn
Funding amount

60k+
Jobs created by startups

3X
Return Generated by Government Fund of Funds scheme for startup investment

Source: KSUM portal

Case for developing an emerging technology hub

The initiative to establish an Emerging Technology Hub in Kerala aims to harness current technological advancements for enhancing the region's innovation ecosystem. This effort seeks to align Kerala's strengths with global trends, fostering sustainable economic growth and technological leadership. The following section outlines the rationale and strategic imperatives driving this proposition.

Inflection point

The current phase marks a critical juncture in technological evolution. The aim is to proactively shape Kerala's innovation ecosystem to capitalize on this paradigm shift.

Shift in production

The shift to a knowledge economy requires a recalibration of production factors towards computation, intellectual property, and talent. This adaptation is crucial for enhancing competitiveness and resilience in the global economic arena.

Sectoral Synergy

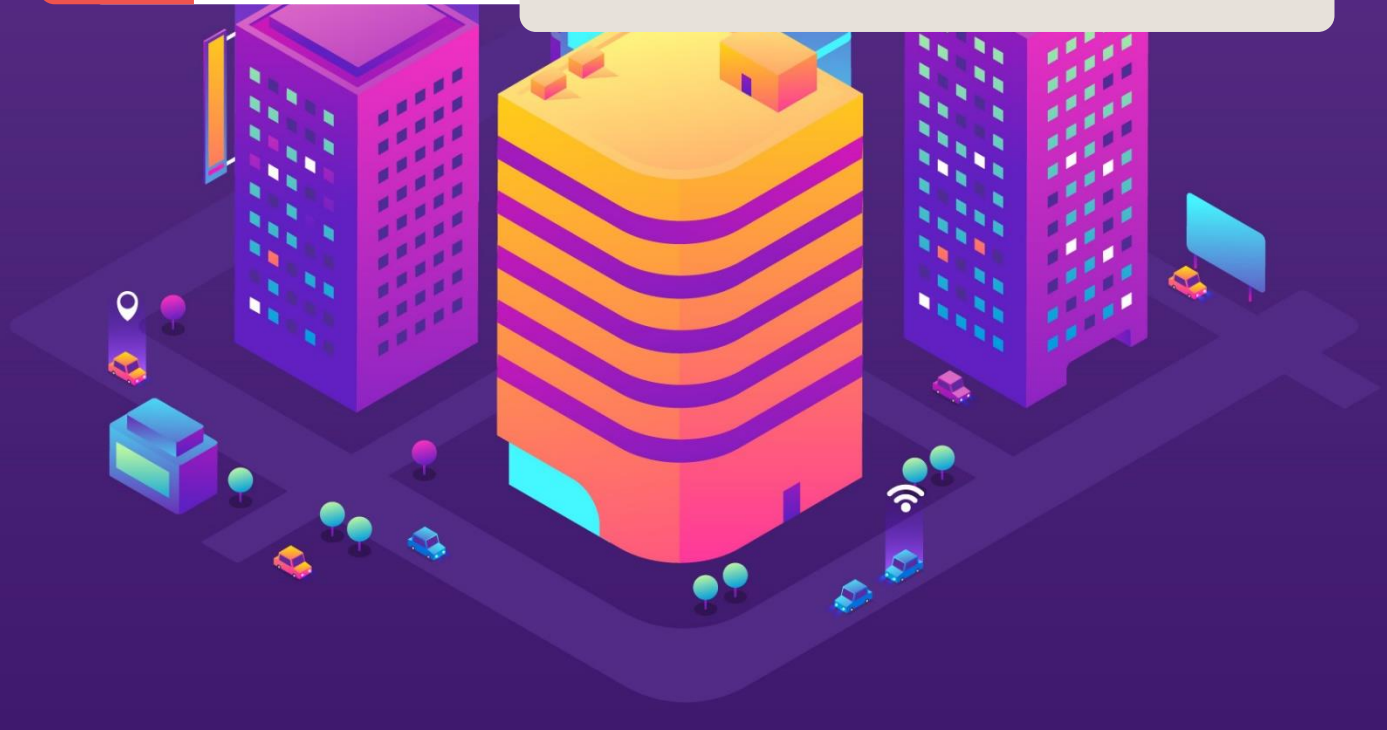
Aligning sectors with competitive advantages in Kerala with the innovation ecosystem is essential. This alignment will enhance the capacity to drive sustainable economic development and technological advancement.

Private Sector Engagement

Establishing a platform for private capital infusion into innovation is imperative. This initiative will facilitate accelerated growth and development through strategic investments in emerging technologies.

Proximity to innovation

As the primary agency closely involved in innovation initiatives across Kerala, KSUM has good proximity with the local innovation ecosystem as well as the diaspora engaged in innovation.



3.

Emerging Tech Hub (EMTH) Overview

Vision and Mission

Vision

To position Kerala among the top 5 global destinations for startups & innovation in emerging technologies, with a particular focus on a defined set of sectors.

Mission

- Secure investments totalling INR 8,300 crore (approximately USD 1 billion) in the emerging tech startup ecosystem in Kerala by 2035.
- Establish equity partnerships with these startups to enhance their growth and sustainability.
- Achieve a collective valuation exceeding INR 830 crore (approximately USD 100 million) by 2035 for EMTH for all its investment vehicles stakes combined.

Objectives

- Anchor programmes in identified technologies and sectors, fostering an enabling environment for startups to innovate.
- Follow an outside-in strategy to attract startups and high-net-worth individuals (HNIs) to Kerala from other regions within the defined industry sectors and emerging technologies.
- Serve as a trusted conduit for sourcing HNI and venture capital investments focused on the designated industry sectors and emerging technologies within Kerala.
- Act as an appealing value proposition for larger corporations interested in the designated industry sectors and emerging technologies to engage and invest in Kerala.
- Develop EMTH into a comprehensive ecosystem supporting innovation throughout the identified sectors and emerging technologies.

Outcomes

- Demonstration of pioneering advancements and breakthroughs in emerging technologies, setting new benchmarks, and shaping global trends.
- Accelerated growth and market expansion among supported startups in emerging technology sectors, catalysing job creation and economic growth.
- Cultivation of a dynamic ecosystem of collaboration and knowledge exchange among industry leaders, researchers, and startups in emerging tech domains.
- Market development for emerging technologies for the startup ecosystem.
- Active participation from corporates either in terms of investments or corporate innovation programs or supporting incubation or acceleration initiatives in startups.
- Recognition as a premier destination for emerging technology innovation, attracting significant investments and partnerships that propel global technological advancements.
- Generation of investments from HNI's, Kerala diaspora into the Kerala Startup emerging tech ecosystem.

EMTH ecosystem components

The EMTH ecosystem will comprise four key components, namely Horizontals, Verticals, Technology Advancement Centres (TAC), and the EMTH Investment Vehicle (EIV). A brief overview of each component is as follows:

- ## Horizontals

  Emerging technology portfolios spanning multiple sectors. In the context of EMTH, Emerging Technologies is defined as:
  - Technologies with potential for future transformative value creation for startups and corporations.
  - Technologies which have an advantage in Kerala context compared to other innovation ecosystems.
  - Technologies with talent and skilling potential for Kerala.

- ## Verticals

  Industry sectors aligned with Kerala's innovation ecosystem.

- ## Technology Advancement Centres (TAC)

  The role of TAC is to enhance Kerala's tech competitiveness in the relevant technology portfolio through market development and capital infusion. The TAC's shall
  - Serve as comprehensive knowledge aggregators within EMTH.
  - Formulate strategic plans to advance the market presence of designated technologies.
  - Lead initiatives in market making and innovation development.
  - Mobilize capital and make strategic investments in associated startups.
  - Execute innovation programs to expand market adoption of EMTH technologies.
  - Develop targeted marketing strategies to promote technology awareness.
  - Facilitate cross-industry collaborations to integrate EMTH technologies.

- ## EMTH Investment Vehicle (EIV)

  Profit-oriented entities dedicated to bringing private sector investment into the emerging tech landscape of the state.

4.

Market Analysis

Emerging tech landscape

There are numerous reports focused on 'Emerging Technologies,' typically providing a forward-looking perspective. However, the objective of this study is to examine and devise strategies for these emerging technologies from a startup viewpoint, particularly within the context of Kerala. In our analysis of emerging technologies, we reviewed perspectives from various authoritative sources, including the MIT Technology Review 2024, Stanford Emerging Tech 2023, the European Commission's 'Eyes on the Future' Report, Gartner's 2024 Emerging Technologies & Strategic Technology Trends 2024, and the World Economic Forum's Emerging Technologies 2024 report, among others. While these reports discuss hundreds of technologies, a few underlying themes unify them. These themes are as follows:

Business reason for technology innovation

There are six fundamental drivers behind most innovations: **(i) the pursuit of sustainability and the transition to net-zero (ii) Drive towards human longevity (iii) enhancements in productivity (iv) need for cost effective & efficient communications (v) the evolution of entertainment (vi) the emphasis on privacy and security.**

Factors driving technology innovation

There are a few underlying factors that are powering innovations, which include:

(i) Advances in fundamental material science are catalysing the development of engineered materials and their diverse applications.

(ii) Material science innovations are driving the evolution of hardware architectures, significantly enhancing computational capabilities at a foundational level.

(iii) The continuous development of sophisticated mathematical and algorithmic models is effectively leveraging increased computational power.

(iv) Enhanced computational capabilities are facilitating deeper insights into cellular and genetic mechanisms, advancing our understanding of biological sciences.

As part of the evaluation of emerging technology innovations, the technologies featured in these reports are grouped into distinct categories or umbrella technologies as outlined below. Each category has been assessed and mapped according to its technology readiness levels (1-3 novel tech, 4-6 emerging, 7-9 closer/in-market).

Sl No.	Categorization / Portfolio Technologies	Emerging Technologies Assessed (Not an exhaustive list)
1	Security & Privacy	Human Centred AI, Responsible AI, Ethical AI, Decentralized Identity, Homomorphic Encryption
2	Genomics	Engineered bacteria in Sustainable Aviation Fuel, Alternative livestock, improved transplant & treatment protocols, spatial omics, xenobots with human cells, DNA Nanobots, DNA traceability for food, bio-foundries, bio-robots
3	Industry Cloud	Platform Engineering, AI Augmented Development, Web3
4	Gen AI	Gen AI, Intelligent Applications, Machine Customers, Creative AI , AI Avatar, Spatial Computing

Sl No.	Categorization / Portfolio Technologies	Emerging Technologies Assessed (Not an exhaustive list)
5	Sensors & IoT	Augmented Workforce, Intelligent Surfaces, Integrated Sensing & Communications, Immersive Tech, paper sensors
6	Connectivity Technologies	High Altitude Platforms, Integrated Sensing & Communications, LEO Satellites, Private 5G, wireless power transfer.
7	AR/VR & Metaverse	Immersive Tech, Digital Twins, Multimodal user interfaces, Mixed Reality Headsets
8	Energy Management Tech	Electrocalorics, Carbon capture tech, enhanced geothermal systems, other sustainable techs
9	Computational Models	Neuromorphic computing, Model Compression, Homomorphic Computing, Tokenization, Blockchain, Knowledge graphs, Scalable Vector Databases
10	Hardware Architectures	Quantum computing tech, AI chips/chiplets, LIDAR on chips, Hyperscale computing, nano magnetic computing, thermal transistors
11	Material Science	Super-efficient solar cells, flexible electronics, anti-microbial packaging, transparent wood
12	Nuclear Tech	New fission/fusion technologies

Table 2. Grouping of emerging tech into categories

The complete list of emerging technologies and their sources have been given in Annexure 1.

The technologies have been mapped into Trigger-1 (fundamental innovations), Trigger-2 (convergence of technologies), and Trigger-3 (heavy regulatory involvement), as illustrated below.

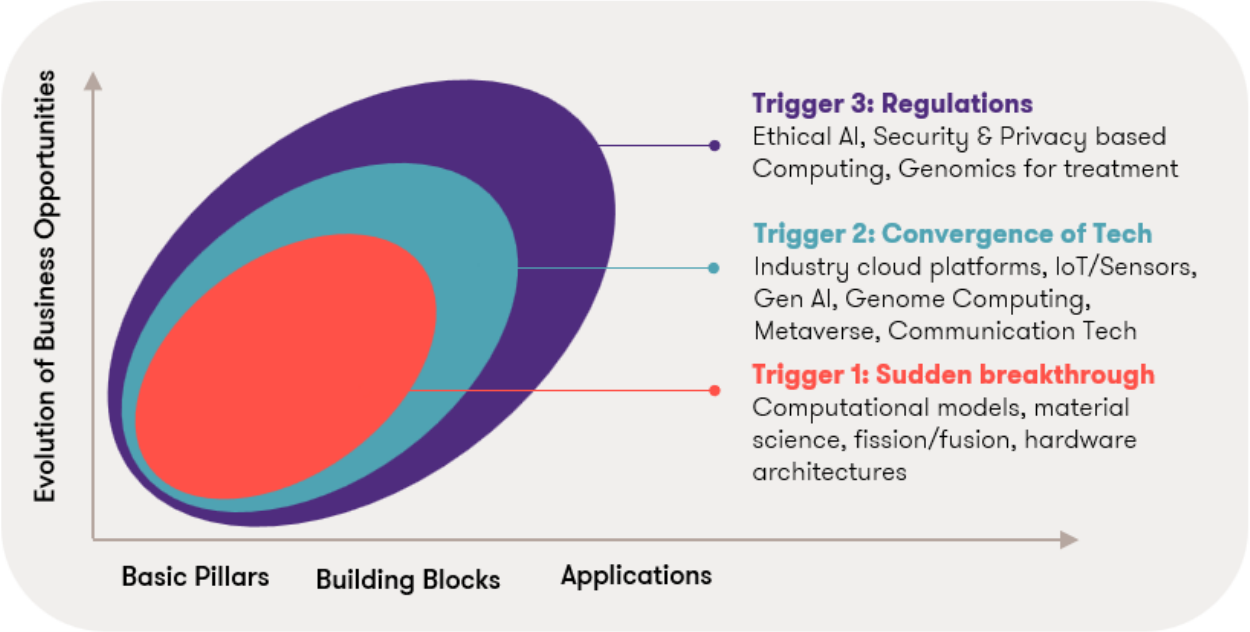


Figure 1: Trigger Model of Technologies (Not an exhaustive list)

The strategic focus of EMTH revolves around Trigger 2 technologies, recognizing the current deficiency in Kerala's ecosystem concerning foundational and regulatory innovations. This gap is intensified by the state's geographical distance from national regulatory bodies. The chosen portfolio of emerging technologies horizontals comprises: **(i) Genomics (ii) Industry Cloud (iii) Gen AI (iv) Sensors & IoT (v) Communication Technologies (vi) AR/VR & Metaverse and (vii) Energy Management & Optimization**. These will serve as the cornerstone **Technology Advancement Centres or TACs**, propelling the engine of EMTH forward.

Subsequently, an assessment was conducted across 13 sectors in Kerala, **(i) Financial Services, (ii) Space, (iii) Healthcare, (iv) Agriculture and Food, (v) Transportation and Logistics, (vi) Digital Media and Entertainment, (vii) Property and Construction, (viii) Education , (ix) Fashion & Jewellery, (x) Life Sciences, (xi) Sports, (xii) Energy and (xiii) Assistive Devices,** aimed at identifying five sectors pivotal to Emerging Technologies. This evaluation was based on nine key parameters –

(i) Talent Base in Kerala
(ii) Expected CAGR in India
(iii) Presence of Fortune 1000 companies within the sector, including GCCs (Global Capability Centres), tech centres, or acquired firms in Kerala
(iv) Number of companies listed in the NSE 1000 headquartered in Kerala within each sector
(v) Presence of large public sector undertakings (PSUs) in the area with specialized technology divisions
(vi) Alignment of Kerala government initiatives with the sector
(vii) Noteworthy startups or privately held firms in Kerala with substantial funding (approximately USD 5 million)
(viii) Relevant sector-related institutes offering graduate and postgraduate programs
(ix) Presence of Micro, Small, and Medium Enterprises (MSMEs).

The detailed sector evaluations are summarized in Annexure 2. The finalized sectors selected for EMTH are: **(i) Space, (ii) Digital Media & Entertainment, (iii) Healthcare and Lifesciences, (iv) Food & Agriculture, and (v) Energy.**

A **technological sector interlock** has been formed based on the Technology Acceptance Criteria outlined below. This interlock focuses specifically on technologies rated at **TRL 4 or above**, which serves as an indicator of the relevance of each TAC and its associated sectors within the context of EMTH. It is within these overlapping domains that **Market-Making Programs** or **Use Cases of EMTH** are expected to emerge. The complete interlock view, including numeric weightages, is provided in Annexure 3.

TECH	SECTOR				
	SPACE	DIGITAL MEDIA & ENTERTAINMENT	HEALTHCARE & LIFESCIENCES	FOOD & AGRICULTURE	ENERGY
Industry Cloud Platforms	✓	✓	✓	✓	✓
Genome Computing			✓	✓	
AR/VR & Metaverse	✓	✓	✓		
Sensor/ IoT	✓	✓	✓	✓	✓
Energy Management & Optimisation	✓	✓	✓		✓
Communications Technology	✓		✓	✓	
Gen AI	✓	✓	✓	✓	✓

Table 3. Sector X TAC Interlock

EMTH aims to cultivate new markets in the intersecting areas through pioneering initiatives that foster collaboration among startups, corporations, academic institutions, government entities, citizen developers, open-source communities, investors, and other stakeholders.

Overview of emerging technology portfolios (horizontals)

Industry cloud platforms

An industry cloud platform is a collection of cloud solutions and applications designed for a specific industry, like healthcare, retail, government, or life sciences. Industry clouds provide solutions for various industries' unique needs, use cases, and content storage, processing, auditing, and securing requirements.

The rise of industry cloud platforms stands out as a significant emerging trend, providing companies with tailored and pertinent industry solutions that add value. These platforms play a key role in expediting the adoption of cloud technologies by specifically targeting business consumers beyond the initial users of cloud infrastructure and platform technologies.

Once the startups which have found a niche in a particular industry realize that they cannot do everything that the industry needs, there is essentially a platform play that is possible in which they open their API's and ecosystem for other startups to plug in their solutions so that the client sees a portfolio of integrated solutions which are suiting their business needs. This is the industry cloud play that is envisaged to happen in many sectors, including all the focus sectors of EMTH.

- **Industry cloud platforms seamlessly integrate underlying SaaS, Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) with a range of innovative technologies and approaches.**
- **From a large corporation perspective, players such as Amazon, Azure and Google Cloud are developing industry clouds for the automotive and financial services industry.**
- **Even from a startup perspective, Startups such as Cropin are developing agro-cloud platforms, Care-Stack with its multiple solutions in the Dental care industry is morphing into a dental cloud ecosystem.**

Genomics

Genomics is a branch of molecular biology that focuses on the structure, function, evolution, and mapping of genomes. A genome is the complete set of genetic material (DNA in most organisms, but Ribonucleic Acid - RNA in some viruses) within an organism. Genomics involves the study of the entire DNA sequence of an organism, including all of its genes and non-coding regions. It has played a significant role in advancing our understanding of various biological processes, evolution, and the genetic basis of diseases.

Kerala being a bio-diversity hotspot is a place where there is high potential for this ecosystem to develop. Recognizing this potential, the Kerala Government has sanctioned a Genome Data Centre project to be executed under the Digital University of Kerala. Leveraging on this, EMTH can focus on developing an ecosystem of startups, which has good potential to disrupt the Healthcare as well as Food and Agriculture sectors. Underlying gene editing technologies such as CRISPR and its variants are being used by innovative startups worldwide.

- **The Human Genome Project, completed in 2003, was a landmark effort in genomics that provided a reference sequence of the entire human genome and paved the way for many subsequent genomic studies.**
- **The combination of Genomic knowledge, rapid genome sequencing, cellular level analysis – all backed by the massive computational power is expected to give rise to large number of opportunities for startups to focus on niche areas and find their mark.**

AR/VR and Metaverse

The global market for Augmented Reality (AR) and Virtual Reality (VR) is booming, as multiple industry sectors are experiencing strong adoption of these technologies. While initially developed primarily for entertainment purposes, AR & VR are now being widely used in areas such as training and productivity-enhancing techniques. Over the past five years, this ecosystem has received a significant boost with the advent of high-performance processors from NVIDIA and the associated developer platforms and tools they have built.

The Metaverse refers to an ecosystem of technologies where the physical and virtual worlds coexist, enabling seamless integration of physical experiences into the virtual realm and vice versa.

Kerala has historically had a strong AVGC (Animation, Visual Effects, Gaming, and Comics) ecosystem, and the state now has an AVGC policy in place. This TAC on AR/VR & Metaverse serves as a powerful lever to further develop the AVGC ecosystem into an AR/VR & Metaverse-centric one, providing benefits to startups.

- **In a study by Stanford University and other collaborating universities VR-based learning produced a 76% increase in learning effectiveness compared with traditional methods (Source – Economist)**
- **"Metaverse is going to be a new economy larger than our current economy" – NVIDIA CEO Jensen Huang**

Energy management and optimization

As explained earlier, one of the fundamental business reasons as to why innovations are happening is the push towards Sustainability and Net-zero. Energy Management & Optimization refers to the portfolio of technologies that help us to optimize and manage generation, storage, transmission, distribution, and consumption. This is an evolving ecosystem. A lot of advanced research based on material sciences is yielding new technologies that could be used at any of the energy phases.

In Kerala, the Centre for Development of Advanced Computing (C-DAC), Thiruvananthapuram, operates as the nodal agency for the National Mission on Power Electronics Technology (NaMPET) phase III program under the Ministry of Electronics and Information Technology (MeitY), Government of India. Within this mission program, C-DAC has put forth a project named 'Smart Power Quality Centre (SPQC) in Distribution Grid.'

There are interesting applications in the Energy management landscape coming up even in sectors such as space with wireless power transfer. Similarly, Kerala has been a pioneer in solar boats. A large Green Hydrogen project is expected to commence in Trivandrum soon. Such opportunities have immense potential for Startups. The TAC on Energy Management & Optimization shall aim to develop this ecosystem working across multiple sectors.

'Smart Power Quality Centre (SPQC) in Distribution Grid.'

The envisioned development of the SPQC encompasses the incorporation of a range of smart grid technologies, coupled with suitable digital communication and power electronic advancements.
This integration aims to transform a segment of the electric distribution network and a substation into a new entity capable of efficiently addressing smart grid functionalities Latest material innovations such as Graphene lab are expected to accelerate position of Kerala in this space further.

Sensors & IoT

A sensor is designed to identify and react to inputs from the physical environment, with common inputs including pressure, heat, light, motion, and moisture, among others. The output is a signal that can be converted into a display readable by humans at the sensor's location or transmitted electronically over a network for reading or subsequent processing. The latest machines are engineered for enhanced safety, flexibility, and efficiency, capable of autonomously monitoring their performance, usage, and potential failures. Consequently, these applications drive the demand for highly sensitive sensors.

Different sensors & IoT's vary in cost, throughput, latency, energy usage, etc. Different businesses may need the right sensors based on these combinations. The Maker Village ecosystem in Kerala has set up a Centre of Excellence in Sensors & IoT. EMTH can leverage the same and work on developing a startup ecosystem.

There are many sensor-level innovations such as paper-based sensors, DNA sensors, etc which are expected to disrupt many traditional sectors. The TAC on EMTH is expected to evaluate these technologies from multiple perspectives when they reach a POC stage and bring forth the attention on them for startups to develop innovative business models.

- **The rise of automation is set to boost the need for sensors, given their key role in detecting, measuring, analysing, and processing various changes, such as alterations in length, position, surface, height, and displacement occurring in industrial manufacturing settings.**
- **The increasing compatibility of sensors with the IoT platform is gradually becoming essential for enabling remote monitoring and control.**
- **Additionally, the Industry 4.0 revolution, characterized by machines becoming more intuitive and intelligent, is amplifying the requirement for sensor applications in industry.**

Generative AI

Generative AI generates outputs in response to prompts, which can take the form of texts, images, videos, and various other inputs. GenAI models leverage extensive existing content to create novel outputs, utilizing neural networks to handle intricate patterns. A Large Language Model (LLM) is an artificial intelligence system created to comprehend and produce human language. An LLM is an AI model that can understand text prompts and produce life-like responses resembling humans.

LLMs are made using deep learning techniques with the help of a neural network called Transformer architecture. Ongoing research and development in the field of artificial intelligence are dedicated to enhancing the capabilities and efficiency of these models, while simultaneously addressing ethical and societal concerns associated with their deployment.

In an Indian or Kerala context, there is a lot of potential for implementing vernacular language-based large language models. Already corporates such as Microsoft are putting a lot of investment in that area. Smarter domain-focused virtual assistants backed by focused Gen AI models are expected to emerge in the next 5 to 10 years. Such an ecosystem paves the way for immense possibilities for startups to innovate. The Gen AI TAC shall focus on such emerging innovative areas and develop an ecosystem which is tuned for such startups.

A notable characteristic of neural networks is their ability to discern patterns in training data without human intervention. Consequently, they identify patterns within prompts, continuously adjusting parameters through sampling to improve the likelihood of producing precise and tailored results. This iterative process ensures the generation of accurate outcomes aligned with user requirements.

Communication Technologies

Communication technologies, in tandem with sensors and IoT devices, form the backbone of modern connectivity. Alongside ubiquitous protocols like Bluetooth, Wi-Fi, and Cellular technologies, a suite of technologies known as LPWA (Low Power Wide Area) technology, including LoRA and NB-IoT (Narrowband IoT), as well as Near-Field Communication (NFC), play pivotal roles in a multitude of sectors.

While high-throughput technologies like Wi-Fi and upcoming standards like 5G and 6G require substantial regulatory support, EMTH shall prioritize the innovative potential of low-throughput technologies due to their potential for widespread application. Similarly, there is a lot of innovation happening on the front of integrating communication and IoT devices. Also, the satellite communication technologies are also evolving quite fast. The TAC on communication technologies shall focus on developing the innovation ecosystem around these aspects.

- **These communication technologies are in a state of rapid evolution, with each finding its niche depending on technological attributes and economic considerations.**
- **The technologies, protocols being used in the satellite realm are rapidly changing so that it is an opportune time for startups to focus and innovate in that area.**

Overview of focus sectors (verticals) in EMTH

Space

The space sector, a dynamic realm withing emerging technologies, encompasses a wide range of activities and industries focused on the exploration, utilization, and commercialization of outer space. This sector includes satellite communications, remote sensing for Earth observation, navigation systems, space tourism, scientific research missions, and ambitious plans for resource extraction from celestial bodies. Today, the space sector is distinguished by rapid advancements in propulsion systems, technology miniaturization, and an increasing presence of private companies alongside traditional governmental agencies. Substantial public and private investment drives growth fostering a competitive landscape that spurs innovation. Collaboration among international space agencies, aerospace corporations, startups, and academic institutions further accelerates progress. However, many initiatives within this sector involve rigorous regulatory considerations and collaboration with agencies like NASA and ISRO. Beyond enabling scientific discovery and technological advancements, the space sector holds significant potential for economic development and sustainability, poised to reshape our understanding of the universe and create new opportunities for societal and commercial benefits both on Earth and beyond.

Sector tailwinds.

- Increased availability & reduced cost of satellite tech
- Innovations in low-cost propulsion technologies
- Computing power aiding in the rapid processing of unstructured data
- Governments have opened up sectors for private players

Top services/Key sector trends

- Ground Station as a service on multiple cloud platforms
- LEO satellite focus by large firms as well as small firms
- Multiple sectors such as Climate, Agriculture, Aviation, increasingly relying on more satellite data

Kerala – Sector landscape

16%

Expected CAGR in India from a base of $8 Billion USD in 2022

10,000+

Est Space-Tech & Engineering Talent Base in Kerala

Key players:

- **PSUs:** KELTRON, Steel and Industrial Forgings Limited (SIFL), Travancore Cochin Chemicals (TCC) and Kerala Automobiles Ltd (KAL)
- **Institutions:** NIST, IIST, IISER, DUK
- **Research centre:** Vikram Sarabhai Space Centre – ISRO, LPSC, IISU
- **Startups:** Sat-sure, HEX20

Government initiatives

- INSPACE anchoring Government of India Space economy initiatives. INSPACE plans to increase the present global market share from 2% to 8% by 2033 targeting USD 44 Billion revenue.
- KSPACE by the Kerala Government set to augment the space economy program in the state through collaborations & infrastructure investment.

Partnerships

- Four Kerala PSUs—KELTRON, SIFL, TCC, and KAL—contributed indigenously developed products to India's first solar exploration mission, Aditya-L1
- KSPACE exploring collaborations with multiple foreign space agencies.

Sector trends relevant to Kerala

- Satellite insurance market to see high growth in which Allianz which has a large tech presence in Kerala is a key player.

Digital Media & Entertainment

The Digital Media & Entertainment sector encompasses a broad range of industries that leverage digital platforms to create, distribute, and monetize content. At its core, this sector revolves around delivering entertainment, information, and interactive experiences through digital channels such as streaming services, social media platforms, online gaming, digital advertising, and virtual reality environments.

Content creators, media companies, and tech giants play pivotal roles in shaping this landscape, constantly innovating to meet evolving consumer preferences and technological advancements. From streaming movies and music to interactive gaming experiences and immersive virtual realities, this sector thrives on engaging global audiences and pushing the boundaries of entertainment.

Sector tailwinds

- AR/VR, and increased adoption of cloud computing.
- Metaverse
- Short film making & Streaming applications
- Preference for interactive learning content rather than planned text, images, or video

Top services/Key sector trends

- Bridging the physical and digital world or unifying experiences
- Augmented Reality headsets like Vision Pro by Apple, Quest by Meta
- Integrated development ecosystems such as NVIDIA Omniverse

Kerala – Sector Landscape

10-15%

Expected CAGR in India from a base of 46 Billion USD In 2023

5000+

Est AR/VR - Tech Talent Base in Kerala

Key players:

- **Media houses:** Kerala is home to prominent media houses like Manorama, Mathrubhumi etc.
- **Companies:** Aries Epica, Toonz Academy
- **Startups:** Eunoians, iBoson innovations, BuildNext, XR Horizons, Tiltlabs

Government initiatives

- Toonz Academy, the academic wing of Technopark-based Toonz Animation, is the first authorised training centre of visual effects software NUKE in the state.
- Kinfra Film and Video Park is India's first Infotainment Industrial Park. It is also the first SEZ in India for animation and gaming.
- Kerala has come out with AVGC policy.

Partnerships

- Under AVGC policy, further partnerships in this sector need to be explored.

Sector trends relevant to Kerala

- Tourism experiences will be increasingly ported to an AR/VR world once headsets such as Vision Pro become mainstream.
- Training materials in multiple domains being ported to AR/VR.

Healthcare & Life Sciences

In the realm of emerging technologies, the healthcare and life sciences sector are undergoing a substantial evolution driven by innovation and digital integration. This evolution encompasses a broad spectrum of advancements aimed at enhancing healthcare delivery, patient care, and operational efficiencies. It involves the application of novel methodologies in diagnostics, treatment planning, and patient management.

Additionally, there's a focus on leveraging data analytics to derive actionable insights, develop personalized medicine to tailor treatments, develop new vaccines, and for the integration of telemedicine for remote consultations and monitoring. These developments not only seek to improve medical outcomes and streamline processes but also strive to make healthcare more accessible and equitable, bridging gaps in healthcare delivery through technological innovation. The sector's evolution continues to shape a future where healthcare is increasingly interconnected, data-driven, and responsive to individual patient needs.

Sector tailwinds

- Computing power aiding in rapid processing of data aiding in tech such as genomics becoming mainstream.
- Electronic chips increasingly assuming the ability to interact with the human body.
- Data Privacy gaining prominence

Top services/Key sector trends

- Personalized medicine and treatments driven by genomic and microbial analysis.
- Expansion of telemedicine and digital health platforms, enhancing rural areas.
- Biosensors and devices like Neuralink enabling real-time health monitoring.
- Industry cloud ecosystems integrating healthcare stakeholders for seamless delivery.
- Growth in microbiome-based interventions.

Kerala – Sector landscape

15-17%

Expected CAGR in India from a base of USD 372 Billion in 2023

10000+

Health - Tech Talent Base in Kerala

Key players:

- **Healthcare companies:** IQVIA, Aster DM Healthcare
- **Startups:** OrthoFX ,Carestack, Sascan
- **MSMEs:** Agappe, Dentcare, HLL, Palakkad surgicals
- **Institutes:** Rajiv Gandhi Centre for Biotechnology, RCC is a premier cancer care institute, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Institute of Virology

Government initiatives

- Pioneers in the establishment of India's first Genome Datacentre. The forthcoming Genome Datacentre is dedicated to sequencing genetic information.
- Kerala Medical Technology Consortium (KMTC) aims at positioning the state as a Global destination for medical technology and devices.

Partnerships

- Multiple partnerships by Sri Chitra and RCC
- KMTC anchoring multiple collaborations with different entities.

Sector trends relevant to Kerala

Karkinos Healthcare which focuses on early-stage cancer treatment, enters collaborations with multiple hospitals with Kerala as a primary market.

Food & Agriculture

The Food & Agriculture sector encompasses the cultivation, processing, distribution, and consumption of food and agricultural products. It is a vital industry that supports global nutrition and food security while also significantly contributing to economies worldwide. The sector includes a wide array of activities such as farming, animal husbandry, fisheries, forestry, and agro processing. It operates within a complex supply chain that connects producers to consumers, ensuring the availability of food products in various markets.

This sector is increasingly influenced by evolving consumer preferences for healthier, sustainable, and ethically sourced food. As the country and state urbanizes, labour availability will be an issue in this sector. While the state has taken initiatives to aggregate land parcels and make them available for agriculture, technology will have to become an enabler in this sector to increase productivity with minimal human intervention.

Sector tailwinds

- Sensors, IoT, and low-power communication technologies driving precision agriculture.
- Genomics becoming mainstream.
- Consumer preferences for fresh food driving enormous business opportunities.

Top Services/Key sector trends

- Modular farming aided by crop specific technologies, automation, and algorithms.
- Nutrient enrichment of food becoming a distinct segment in the food processing industry.
- Ecommerce firms focusing on shortening farm to fork cycle. Emphasis of fresh meat & fish increasing a lot.

Kerala – Sector landscape

15-20%

Expected CAGR in India from a base of $239 billion USD in 2023)

5000+

Est Tech Talent Base in Kerala

Key players:

- **Startups:** farmersfz.com, freshtohome.com, Fuselage Innovations, uFarms.io etc.
- **Companies:** Orkla, acquired 67 per cent stake in the well-known Kerala-based spice-maker Eastern Condiments.
- **Institutes:** RG Biotech, Kerala Agricultural University, NIST

Government initiatives

- Kerala Government has created an Organic Farming Mission to encourage the adoption of sustainable organic and climate-smart farming practices in the State.
- KINFRA Food Processing Park, Sea Food Park, Herbal Park, Primary Processing Centre, and Cold Storage etc.

Partnerships

- Collaboration between FPOs, the World Bank, and the Resilient Kerala Program underlines a strategic partnership aimed at promoting agricultural resilience in the state.

Sector trends relevant to Kerala

- Food processing industries expanding their presence in the state.
- Nutraceuticals is emerging as a key opportunity for Kerala to focus on.

Energy

The energy sector plays a critical role in the production, distribution, and consumption of essential resources that power societies and economies. As a power-deficit state, Kerala currently relies on external sources, primarily thermal & nuclear power, to meet its energy needs. Addressing this ongoing shortage requires focused, long-term investments in solar and nuclear power generation.
Concurrently, the shift toward net-zero targets and sustainable practices is driving a new market for energy management, storage, and distribution startups. This shift aligns with Kerala's need for resilient energy solutions, opening avenues for smart grid innovations and renewable integration. In the U.S., there is renewed interest in Small Modular Reactors (SMRs) to power energy-intensive sectors like data centres, with multiple startups expected to deploy SMR solutions by 2030. In India, however, the regulatory framework for SMRs is still in its early stages, representing both a challenge and a future opportunity for adaptation.

Sector tailwinds

- Net-zero focus
- Sustainability initiatives
- Green Hydrogen development
- Expansion of Green Finance

Top Services/Key sector trends

- Advanced Energy management and optimization solutions
- Smart grid systems
- Innovative Energy storage technologies - advanced batteries and grid-scale storage.
- Growing focus on EV, Green Hydrogen
- Emergence of Small Modular Reactors (SMR) in the US, EU & China.

Kerala – Sector Landscape

9-12%
Expected CAGR in India from a base of USD 22 Billion (2023) (renewable)

10000+
Est Energy-Tech Talent Base in Kerala

Key Players:

- Notable players in the sector include Government-owned entities like GAL, BPCL Kochi, and Cochin Refinery & Baker Hughes
- ANERT
- Kochi-based solar-electric boat manufacturer Navalt

Government Initiatives

- EV Policy & e-Bus initiatives
- LNG Terminal in Kochi
- Energy Management Centre (EMC)

Partnerships

- One of the latest developments in this sector is the Green Hydrogen project announced by NASDAQ-listed ReNew in Thiruvananthapuram, near Vizhinjam. This project has the potential to transform the hydrogen sector across the state.

Sector trends relevant to Kerala

- The Green Hydrogen project near the Vizhinjam port, located close to international maritime channels, serves as a powerful catalyst for the sector.

Comparative global models

The Emerging Technology Hub is envisioned as a combination of for-profit and non-profit sub entities, capable of engaging corporates in various aspects of local ecosystem development. A comparison with ecosystems from different parts of the world highlights key factors relevant to the Emerging Technology Hub. While India currently lacks a directly comparable ecosystem, insights from global hubs are examined to guide its development.

MBC Biolabs – San Francisco

This Silicon Valley's leading biotech ecosystem features leading corporations like Johnson & Johnson, AbbVie, and Eli Lilly, investing in infrastructure to advance pharmaceutical research and commercialization. Distinguished by patient corporate venture capital, it reflects a strategic, long-term investment approach, unlike traditional incubators.

Key Takeaway
Competing Corporate entities can collaborate on innovation and invest in cutting-edge, high-cost hardware infrastructure for collective benefit.

Hsinchu Science Park - Taiwan

Backed by Taiwan's government, the high-tech ecosystem capitalized on a semiconductor boom, nurturing firms like TSMC and UMC. Specialization led to distinct entities, strengthening competition and growth.
By 2022, it hosted 567 companies with 175,000 employees, generating around USD 51 billion annually.

Key Takeaway
A strong trend can be identified upfront, it is possible to develop an ecosystem around it with many initiatives.

IIT Madras Research Park

Has cultivated an academic ecosystem fostering startups, with professors collaborating closely with local corporates and investing in IIT-affiliated firms. Notable successes like Ather have boosted its reputation, leading to significant local ecosystem growth. Today, it focuses on pioneering technologies like Hyperloop, pushing the boundaries of innovation.

Key Takeaway
Collaborating with academics to commercialize their intellectual assets enhances the Hub's relevance and industry profile

Tel-Aviv / Israeli Innovation Ecosystem

Before 1995, Israeli innovation centred on military tech, shifting post-1995 to include cybersecurity and broader global market growth. Firms like Checkpoint exemplifies this shift. The ecosystem now emphasizes global markets due to limited domestic opportunities. Diaspora ties to the US drive talent exchange. Initiatives like the Yozma Program strengthen local capital flow.

Key Takeaway
Innovation success is driven by its strategic shift from defence to cybersecurity, supported by strong diaspora ties and proactive government funding initiatives.

5.
EMTH Strategy & Operating Model

EMTH strategy

EMTH integrates innovation, infrastructure, collaboration, and strategic funding to lead in emerging technologies and drive global impact. EMTH focuses on two core areas: constructing tangible physical infrastructure such as laboratories and specialized equipment, and developing intangible components such as digital assets, industry standards, intellectual property, and strategic partnerships. It prioritizes prompt initiation of initiatives, recognizing that infrastructure development may involve considerable time and resources. EMTH aims to establish a compelling value proposition within targeted sectors through five strategic elements:

1. **Cutting-Edge Digital Assets:** Curate and deploy next-generation technologies such as advanced AI models, immersive Metaverse platforms, open APIs and curated datasets that redefine industry standards.
2. **State-of-the-Art Infrastructure:** Provide world-class laboratories and specialized equipment for agile prototyping and pioneering research in emerging technologies.
3. **Universal technological standards:** Adopt and promote open standards for seamless integration and global scalability. This approach ensures seamless integration and compatibility among various components, promoting collaboration among startups, corporates, and academia. It simplifies development efforts and enhances the scalability of technological solutions.
4. **Partnerships:** Cultivate markets through strategic partnerships with innovative startups, forward-thinking corporations, Government entities, and leading academic institutions. This synergy enhances EMTH's ability to create compelling value propositions, attract investment, and accelerate the adoption of groundbreaking innovations in emerging technology sectors.
5. **Access to diverse funding options:** EMTH aligns with national, international, and regional funding initiatives, along with corporate and private investment opportunities. This ensures access to diverse funding sources vital for sustainable growth and ongoing innovation in emerging technologies.

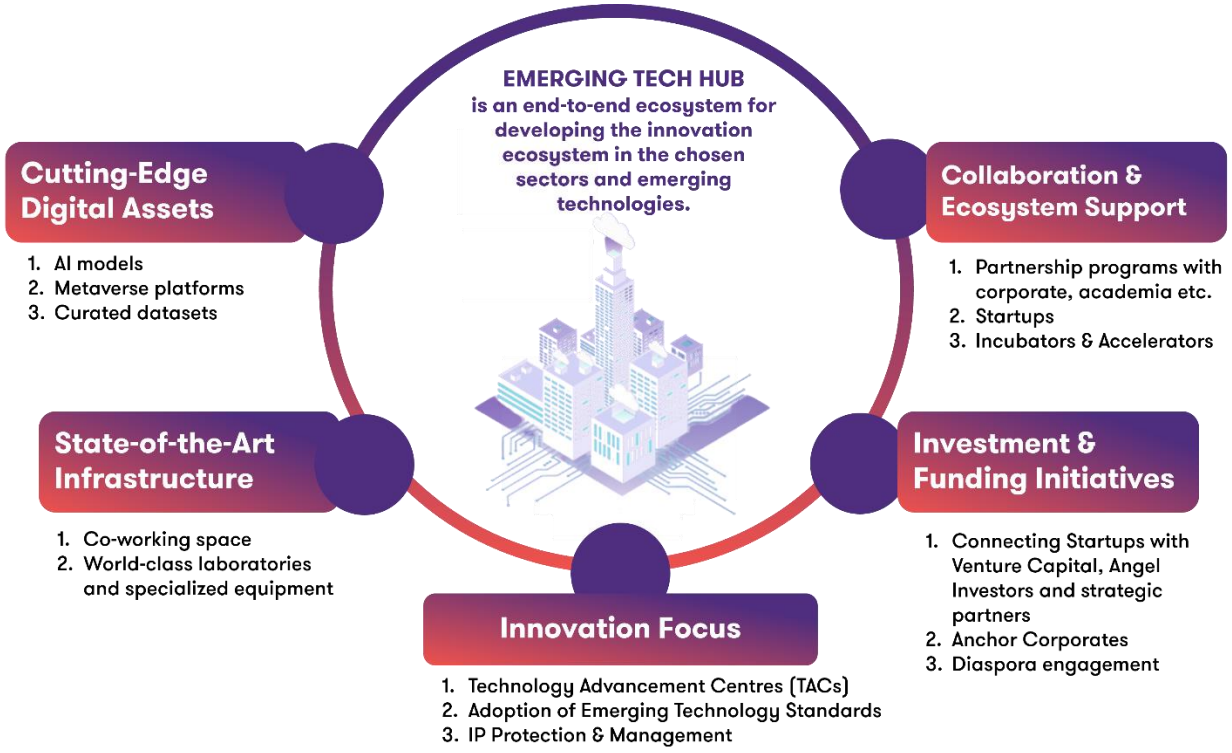


Figure 2: EMTH Strategy Framework

EMTH structure and operating model

The initial equity contribution will come from KSUM or an equivalent non-profit/Section 8 company under Govt of Kerala. There shall be a private investment vehicle under EMTH into which external investors shall be able to invest for a return. The non-profit entity also can invest into the for-profit entity.

EMTH shall serve as the overarching governing body of the EMTH programme, owned by the Department of IT, Government of Kerala, and managed by KSUM. All physical infrastructure funded by government grants, loans, or CSR initiatives shall be managed by the EMTH non-profit entity. EMTH shall run market-making programmes and develop use cases across various technologies and sectors through its Technology Advancement Centres (TAC). Once a sustainable network of startups is established around a TAC, a for-profit strategy will be introduced with an anchor investor. This will allow startups associated with the TAC to engage in equity or revenue-sharing arrangements. These for-profit ventures shall be structured as EMTH Investment Vehicles (IV). These investment vehicles shall be housed under the for-profit entity. In a matured state, the overall structure can be visualized as below.

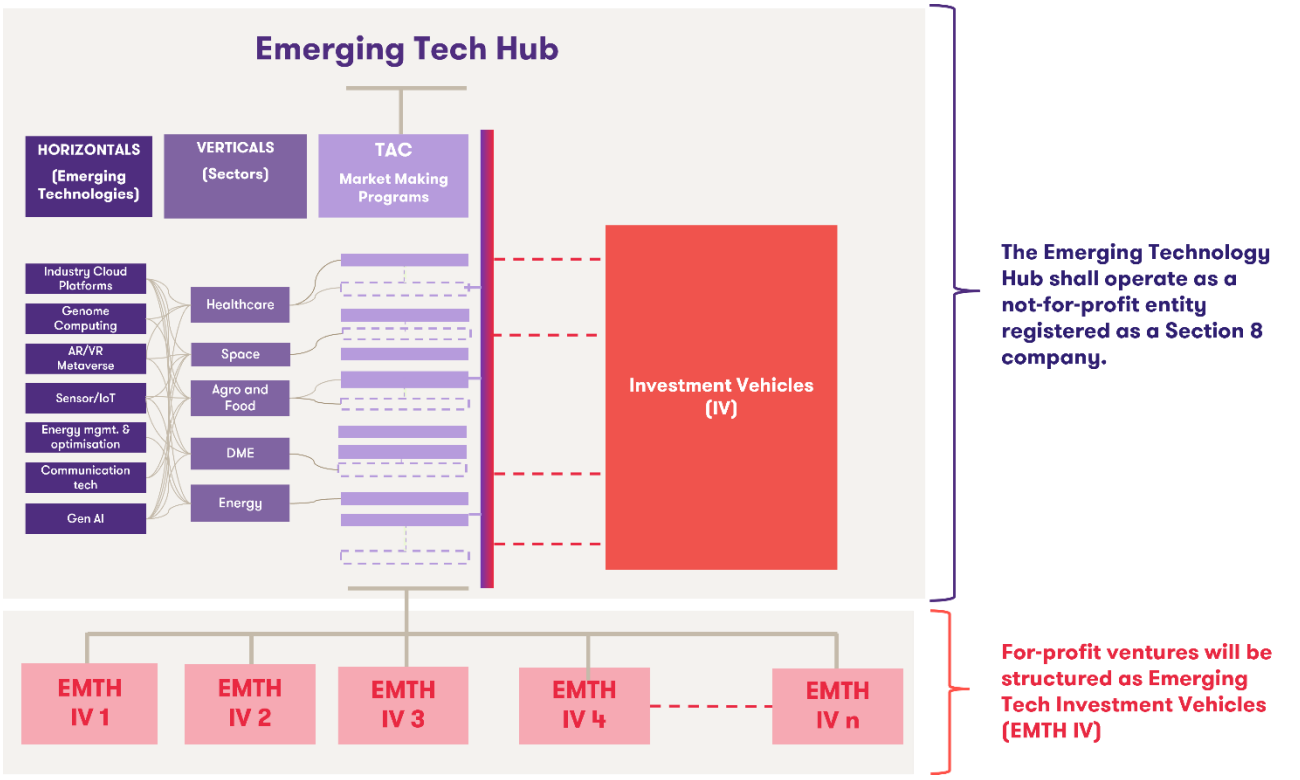


Figure 3. EMTH Incorporation Structure

At the foundational level, the establishment of open frameworks driven by software and hardware, the open-source community, talent and skilling frameworks, existing industry standards, and engagement with academic institutions provides a robust groundwork for developing digital assets.

Nationally, the presence of robust digital public goods/infrastructure such as Aadhar, UPI, and ONDC has ushered in an era of technology-enabled applications. In subsequent phases, numerous sector-specific digital assets will emerge, including sector-specific stacks, industry cloud ecosystems, and large language models (LLMs) that facilitate AI applications. EMTH initiatives within each sector will focus on forging a cohesive ecosystem of digital assets that startups or corporations can leverage to nurture further innovation ecosystems.

The EMTH operating model will comprise three main phases: **1) Set-up base, 2) Pilot, and 3) Scale.**

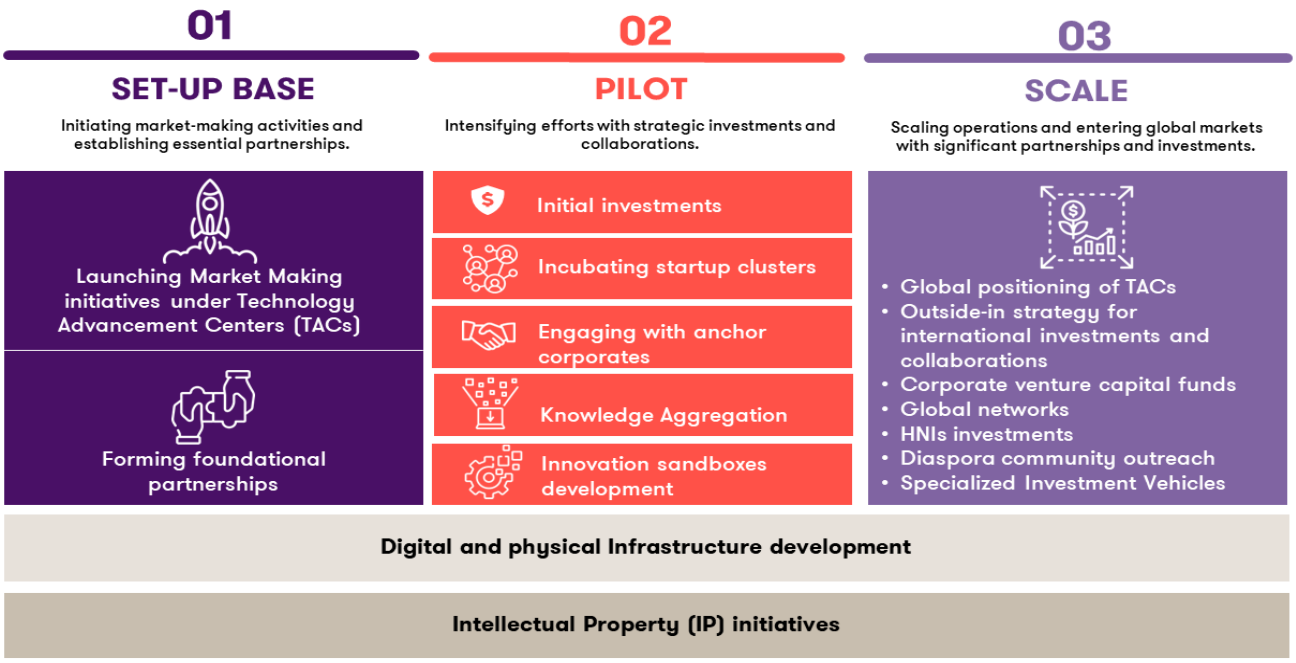


Figure 4. EMTH Operating Model

During the **Setting Up of the Base phase**, the focus will be on developing market-making programmes under the TACs to provide opportunities for startups to evaluate use cases in identified focus technologies and sectors. Additionally, a set of foundational partners will be onboarded who embrace open standards and frameworks, enabling startups to collaborate effectively. The market-making programmes within each TAC will be grounded in this overarching strategy, developing sector-specific ecosystems that drive innovation forward.

In the **Pilot phase**, the market-making programmes will be further scaled up to incubate startup clusters, generate initial investments, engage potential anchor corporates, and aggregate knowledge to build the overall value proposition of TACs and EMTH. These market-making programs are detailed in section 6. Once the pilot phases are successful, the focus will shift towards scaling up the TACs and positioning them globally. For example, if pilots on interactive movies succeed and form a startup cluster in that area with sufficient knowledge aggregation, sandboxes, and partnerships at a TAC level, the focus will be on positioning the TACs, highlighting those capabilities and the innovation cluster to the global tech industry.

The **scale-up phase** will focus on international investments from HNIs and the diaspora, connecting the TACs to global networks. If sufficient investment interest is generated, the relevant market-making programmes under one or more TAC will be spun off as a for-profit investment vehicle for investors or funds to participate in.

6.

Market Making Programs

Overview of Market-making Programs

Most strategies on emerging technologies adopt a wait-and-watch approach before committing significant investments. However, Kerala aims to secure a leading position in this domain by employing forward-looking strategies to influence markets, with EMTH as the focal point. The idea is that once markets in emerging technologies are established, the local ecosystem will naturally attract startups, corporates, and investors. Similar strategies have been successfully implemented globally. For example, Israel nurtured a cybersecurity market by focusing on the defence sector, while the European Union developed markets for elderly care solutions through innovative programs. Governments worldwide are strategically investing in the hydrogen economy and electric vehicle markets.

A summary of the market-making programs envisioned under EMTH is provided below. The Technology Advancement Centres (TACs) will continuously identify and implement additional programs to further enhance the innovation ecosystems under EMTH. This list is not exhaustive and will evolve as TACs operate.

The following conditions are essential in determining whether an initiative or use case qualifies as a market-making program:

1. **Market Development Potential:** Can EMTH, in collaboration with ecosystem partners, develop a sustainable market for startups within the selected Sector x TAC combination within a defined timeline?
2. **Global Relevance:** Are startups in this specific area gaining traction globally, indicating market demand and potential growth?
3. **Regulatory Feasibility:** Do current Indian regulations support or show adaptability to this initiative or use case?
4. **Technological Maturity:** Only technology use cases with Technology Readiness Level (TRL) 4 and above are considered, ensuring that programs have a foundation for scaling.
5. **Ecosystem Readiness:** Is the local ecosystem equipped with or capable of developing the necessary resources (skills, infrastructure, capital) to support this market?

Sector	Technology Advancement Centres	Market-making Programs	Initial focus applications
Space	**Industry Cloud**	Ground Station as a Service (GSaaS)	Rerouting ships and aircraft to avoid rough seas and turbulent weather conditions.
	Communications Tech	Satellite Communications Labs	Using technology to detect wildlife encroachment, locate lost fishing vessels and detect wildfires.
	Gen AI	Spatial Data Applications	Analysing spatial data to assess wildlife habits and potential threats to evaluate effectiveness of conservation measures. Assess spatial data related to demographics, mobility patterns, health care access to dynamically plan urban environments.
Digital Media & Entertainment	**AR-VR & Metaverse**	Interactive Learning	Creating Interactive learning tools for international driving and training programs tailored for firefighters and oil

Sector	Technology Advancement Centres	Market-making Programs	Initial focus applications
			rig workers.
	AR-VR & Metaverse, Gen AI	Interactive Movies	Creating markets and platforms for interactive movies.
	AR-VR & Metaverse	Metaverse in Tourism	Developing AR-VR tourism experiences within the Metaverse.
Healthcare & Life sciences	**Gen AI**	AI for Health	Setting up information kiosks that disseminate basic healthcare and hygiene information, along with diagnostic assistants for primary health centres (PHC).
	Genomics & AI		
	Genomics & Industry cloud	Early Disease Discovery	Utilising genomics for early disease discovery.
	Industry Cloud	Care Robots - Elderly Care & Active Aging	Care Robots enabled by Gen AI modules for elderly care
Food & Agriculture	**Genomics & Industry Cloud**	Agri-Genomics & Microbiomes	Identifying high-yield crops and optimizing cultivation methods with initial focus on berries
	Gen AI	AI for agriculture	Disseminating agricultural knowledge through kiosks, mobile apps or digital agro advisors in local languages.
	Industry Cloud, Sensors & IoT	Crop specific Farming Stack	Designing crop specific farming solutions tailored for various crops with initial focus on berries
Energy	**Industry Cloud**	Energy Communities	Promoting decentralized & self-sufficient energy systems and facilitating peer-to-peer power exchange.
	Energy Management & Optimization	Energy Optimization	Offering optimization solutions for solar power generators, developing markets for vehicle-to-grid (V2G) solutions, and fixing energy leakages
	Energy Management & Optimization	Hydrogen Valley	Advancing hydrogen as a fuel for maritime and trucking sectors, including related engines technologies.

Table 4: Market Making Programs – Overview

In the following section, each of these market making programs are detailed, highlighting their technological significance for EMTH, anticipated outcomes in terms of digital or physical asset creation, potential collaboration with emerging startups, private sector investments, and more.

Space

Industry Cloud | Celestial Connect - Ground Station as a Service

Along with the LEO Satellite boom, ground stations, which are essentially up linking and downlinking facilities for satellites also need to be set up across the world. The technology for ground stations is also evolving at a rapid pace. Startups that can setup Ground stations, can offer those as a service either through established cloud players such as Azure, AWS, etc. or by themselves. Essentially, Celestial Connect - Ground Station as a Service is a key industry cloud solution for the space sector. As even a single LEO satellite would need multiple ground stations, the services offered by the Ground Stations in India could be leveraged by other countries as well.

Satellite Ground station Market, presently assessed at about $70 Billion is expected to grow to $270+ Billion by 2034

Technological significance for EMTH

Current initiatives in the evolving space technology ecosystem largely focus on capital-intensive spacecraft and launch vehicle technologies, often requiring specialized licenses. However, for a robust space-tech sector to flourish, expertise in up linking and downlinking is essential. Hence having a cluster of startups centred around Ground Station Technology is critical for the space sector to flourish.

As more players emerge capable of establishing and commercializing ground stations, the local ecosystem will naturally develop the necessary up linking and downlinking expertise. College students in Kerala are setting up ground stations as academic projects already. This nascent talent base could be strategically developed by EMTH to develop a pipeline of new startups in this sector.

ESA (European Space Agency) also does a similar initiative to aggregate and provide a pay-per-use ground station market for small satellite players

Envisaged outcomes

The **Industry Cloud** Technology Advancement Centre (TAC) shall anchor all the initiatives for ground station as a service.

Market making

Industry Cloud TAC shall develop a market for ground stations by bringing together startups which can offer ground station as a service, satellite data analytics firms as well as corporates or government which are in need for solutions based on satellite data. Convergence of these three stakeholders can develop a market. As a start, EMTH shall focus on startups using LEO satellites for a variety of needs such as **Ship and aircraft rerouting to avoid rough seas and turbulent weather.**

Digital assets

Over a period, the industry cloud TAC shall envisage developing a set of open frameworks and APIs that can be leveraged on these ground stations. Similarly, a core knowledge aggregation is envisaged to happen in this technology under this TAC.

Potential collaboration with emerging startups

1. RBC Signals – Emerging Ground station and connectivity provider.
2. LeanSpace– Cloud Native Satellite Command & Control, Planning solutions
3. Mission Space- Advanced Weather Analytics

Private sector investments

Once the market for this service develops, large ground station as a service provider such as AWS, Azure Orbital may look at Kerala from an investment perspective as the talent and market ecosystem would have developed by then. Similarly largescale LEO satellite firms such as One-Web and Starlink could also be approached for strategic investment into the TAC.

Space

Communications Tech | Orbital Nexus Labs - Satellite Communication Labs

As the satellite market evolves, multiple types of applications shall require various kinds of detection equipment as well as communication technologies and protocols to be used on a satellite. Technologies used for detecting and communicating climatic disturbances will be very different from technology to detect and communicate wild-life encroachment or telephone or internet signals in remote places.

Global Satcom equipment market is projected to reach $39 Billion in 2028 from the present market size of $20 billion

Technological significance for EMTH

In addition to the Ground stations expertise described in the earlier section, the detection & communication protocols and technologies for different situations are evolving. For the space economy to develop and attract more investments, it is essential that innovation in space centric detection & communication technologies is nurtured. While many experimental satellites are being launched by startups as well as colleges, it is important that these innovations graduate into genuine business cases. To catalyse this shift, satellite communication labs shall focus on developing an expertise to identify and recommend the right type of detection and communication equipment for a given business case. It could also monitor emerging technologies such as wireless power transfer in space to see how these could be applied in real situations.

EU is developing a secured space-based communications system with an overall budget of €6 billion. This is expected to spawn many opportunities for startups both in EU and globally.

Envisaged outcomes

The **Communications Tech** Technology Advancement Centre (TAC) shall anchor all the initiatives for Sat-comm Labs.

Market making

Communications Tech TAC shall develop a market for sat-comm labs. Given a problem statement which would need a satellite-based detection, the sat-comm lab shall be able to recommend the right kind of detection and communication technologies as well as connect to the relevant startups which can offer the relevant solutions. As a start, sat-com lab shall work on developing market for problems such as **detecting wild-life encroachment, locating lost fishing vessels & wild-fire detection.**

Digital & physical assets

Over a period, the communications TAC shall envisage to develop a core knowledge aggregation on the satellite communications sector. Similarly, over a period the lab shall have a set of testing equipment as well as sample objects of latest detection and communication

Potential collaboration with emerging startups

1. CareWeather– Innovative Low-cost surface sensing and communication tech
2. Fossa Systems – Satellite IoT solutions
3. NuSpace – Satellite IoT solutions

Private sector investments

Once the ecosystem around Satellite Communications Labs develops, the Communications Tech TAC could become an attractive value proposition for major satellite communications equipment makers such as SES Satellites, Intelsat, Inmarsat, Echostar, General Dynamics etc.

Space

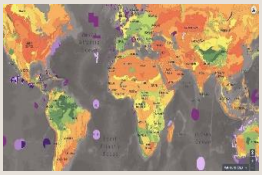
Gen AI | GeoVision AI - Spatial Data Applications

Solving many problems using satellite data would need specialized AI and analytical skills. The Gen AI TAC shall lead the efforts on Spatial Data Applications use cases from a computational perspective to develop the space-tech innovation ecosystem.

Global geo-spatial data analytics market is projected to reach $140+ Billion in 2028 from the present market size of $78 billion.

Technological significance for EMTH

While the earlier use case on Satellite Communication labs focussed on quick detection and communication, there are lot of situations in which Satellite data needs to be analysed by AI models and inferences needs to be made. The proposed use case of GeoVision AI is such a capability that is essential for the innovation ecosystem in state for the space sector to flourish. For a given business problem, the computational needs and AI models would be specific. Initiatives such as the National AI mission plan an outlay of ₹ 10,000 Cr to create computational infrastructure and other related needs. This will be facilitated by tie-ups with initiatives such as UN Bio-diversity Labs.



The UN Biodiversity Lab 2.0 is a free, open-source platform that enables governments and others to access state-of-the-art maps and data on nature, climate change, and human development in new ways to generate insight for nature and sustainable development. It is freely available online to governments and other stakeholders as a digital public good.

Envisaged outcomes

The **Gen AI** Technology Advancement Centre (TAC) shall leverage on such initiatives and create the necessary infrastructure for spatial data

Market making

Gen AI TAC shall develop a market for startups working in spatial data applications. It shall bring together firms having specialized business problems based on spatial data as well as innovators with expertise on managing spatial data applications. To start with, spatial data applications shall work on developing markets for problems such as **identifying priority areas for wildlife protection to evaluate effectiveness of conservation measures, and dynamic urban planning for aging population.**

Digital & physical assets

Over a period of time, the gen AI TAC shall envisage to develop a core knowledge aggregation on the spatial data models. Similarly, over a period of time the gen AI TAC shall have a set of open framework and API's which could be used by startups working on spatial data applications.

Potential collaboration with emerging startups

1. Mission Space – Spatial Data analytics
2. SatSure - Spatial Data Analytics firm
3. Blue Sky Analytics - Spatial Data Analytics

Private sector investments

Once the ecosystem around Spatial data applications develops, the Gen AI TAC could become an attractive value proposition for major spatial data ecosystem players such as Planet Labs, Google etc. If the computational need really takes off, it could attract potential investments from specialized chips as well.

Digital Media & Entertainment

AR-VR & Metaverse | VirtuEd - Interactive Learning

Interactive learning experiences train people using AR-VR simulations of real-life or field situations which is otherwise difficult to emulate in a classroom setting. These are used for trainings of oil rig workers, fire-fighters, precision equipment operators in various industries, etc. Of late, these trainings have been used in the medical field as well.

The global AR-VR based interactive learning market was valued at $3.9 billion in 2023 and is expected to grow to reach $14 billion by 2028 with a CAGR of 29%.

Technological significance for EMTH

Kerala has made a strong footprint in technical training fields using the ITI network as well as initiatives such as ASAP (Additional Skill Acquisition Program). This network needs to be strengthened further in training people for various industry-centric jobs. A significant proportion of expatriate Keralites work in the Middle East, known for a high proportion of industries which have a need to train workers in such specialized skills using AR-VR. EMTH can develop a set of startups that can create a "VirtuEd" interactive learning experience. These could be partnered with different target industries to create a skilled workforce in the state.

A startup – Skillveri - uses Meta's Quest headsets to train industrial workers in skills like industrial painting, welding, and mechanical installation.

At the G20 summit they demonstrated a "Basketball on Moon" experience to teach children on how gravity works

Envisaged Outcomes

The **AR-VR & Metaverse** Technology Advancement Centre (TAC) shall anchor all the initiatives for interactive learning.

Market making

AR-VR & Metaverse TAC shall develop a market for interactive learning by bringing together startups which can offer such services, target industries where there is a need for such experiences, as well as relevant technology partners. To start with, **interactive learning for international driving, oil rig operations and firefighting** may be focused on to build markets.

Digital assets

Over a period, the AR-VR & Metaverse TAC shall envisage developing a strong knowledge curation as well as dedicated software platforms for making interactive learning experiences. The TAC shall infuse technologies such as Haptics as well as advanced AR-VR headsets into the realm of interactive learning.

Key technology collaborations partners

1. Skillveri and similar players
2. VR Headset makers such as Meta & Apple
3. Compute platforms such as NVIDIA Omniverse

Potential collaboration with emerging startups

1. PlayShifu – STEM learning based on AR-VR
2. Simulanis – AR/VR learning for different industries

Private sector investments

Once the market for making interactive learning experiences is developed centred around EMTH, this ecosystem could be provided as an investment vehicle for training providers such as Coursera, or even to large industrial corporates such as Siemens, Thermax, Alstom, Cummins, Honeywell, GE etc. that may have a significant training requirement for their workforce.

Digital Media & Entertainment

AR-VR & Metaverse & Gen AI | Interactive Movies

An interactive movie enables viewers to engage with characters, influencing the storyline based on their interactions. Such movies have the potential to become mainstream within the next 10 years, driven by the increasing availability of processing power, widespread adoption of AR/VR headsets, and advancements in haptic or gesture technology.

The global interactive film and TV market was valued at $40 billion in 2022 and is expected to grow at a CAGR of 15% till 2030.

Technological significance for EMTH

Kerala has a strong AV-GC talent footprint as well as booming movie industry churning out many blockbusters recently. The industry is ripe for a technology-based disruption. Globally the increased availability of compute power for AR-VR processing as well as Gen AI based editing of scripts have resulted in more integration of technology with movies. This is a ripe time for ecosystem initiatives such as EMTH to make a mark in this realm and develop a cluster of startups working in this sector. The startups working in this arena need good amount of compute power as well as strategic partners such as Runway ML. These collaborations shall be stitched together by EMTH leveraging on the compute & AI infrastructure planned by National AI mission.

A significant part of the Oscar winning movie “Everything Everywhere All at Once” in 2023 was made through Gen AI and ML tools developed by Runway ML

Envisaged outcomes

The **AR-VR & Metaverse as well as the Gen AI** Technology Advancement Centre (TAC) shall anchor all the initiatives for

Market making

AR-VR & Metaverse TAC shall develop a market for **interactive movies** by bringing together startups which can offer such services, movie houses which have the script or movie rights as well as technology partners such as Runway ML together.

Digital assets

Over a period, the AR-VR & Metaverse TAC shall envisage developing a strong knowledge curation as well as dedicated software platforms for making such interactive movies. The TAC shall infuse technologies such as Haptics as well as advanced AR-VR headsets into the realm of interactive movies.

Key technology collaborations partners

1. **Runway ML**, the Gen AI & ML library provider for movies
2. VR Headset makers such as **Meta & Apple**
3. Compute platforms such as **NVIDIA Omniverse**
4. GPT platforms such as **SORA**

Potential collaboration with emerging startups

1. **Cinema8** - Interactive movie tools & SDK

Private sector investments

Once the market for making interactive movies is developed centred around EMTH, this shall be a strong case for investment from streaming providers such as Disney-Hotstar or Netflix. It can even generate investment from GPU makers such as NVIDIA to develop the market much more. These startups may see investments from movie houses or distributors or actors who are flush with cash.

Digital Media & Entertainment

AR-VR & Metaverse | KeralaVerse - Metaverse in Kerala Tourism

In future, AR-VR experiences of tourist attraction will proliferate in Metaverse. People will virtually experience such spaces in Metaverse using AR-VR devices, buy NFT's from these spaces. Such Metaverse engagements shall generate interest to physically see these places. When they visit these places, they can redeem these NFT tokens from the actual places and this will further reinforce the network effect and attraction toward such tourist experiences. Essentially, the ecosystem shaped up by AR-VR & Metaverse will influence consumer behaviour and tourist demand significantly.

The global virtual tourism industry was valued at $8 billion in 2023 and is expected to grow at a CAGR of 30% till 2030 to a market size of $39 billion by 2030.

Technological significance for EMTH

Kerala has been a leader in the tourism industry with innovative campaigns like "God's Own Country." However, this competitive edge is gradually diminishing, and the state's tourism sector must reinvent itself in today's technology-driven landscape. The anticipated shift in consumer behaviour presents an ideal opportunity to foster a cluster of startups focused on reimagining tourism through technology, revitalizing Kerala's appeal in the global market. Kerala has been a leader in the tourism industry with innovative campaigns like "God's Own Country." However, this competitive edge is gradually diminishing, and the state's tourism sector must reinvent itself in today's technology-driven landscape. The anticipated shift in consumer behaviour presents an ideal opportunity to foster a cluster of startups focused on reimagining tourism through technology, revitalizing Kerala's appeal in the global market. There is a strong convergence between entertainment, gamification and tourism industries that is foreseen to happen. For e.g., movie locations such as "Kireedom Bridge" as well as literary places such as "Village of Khasak" are being marketed as tourism spots now. If these are converted into AR-VR experiences in Metaverse, KeralaVerse can amplify the tourism potential as well.

Histovery, a French startup has made AR-VR experiences of Louvre Museum, Notre Dame Cathedral as well as historical events such as American war of independence and D-Day landings. These have increased the number of tourists visiting these places

Envisaged outcomes

The **AR-VR & Metaverse** Technology Advancement Centre (TAC) shall anchor all the initiatives for Metaverse in Tourism.

Market making

AR-VR & Metaverse TAC shall develop a market for making tourism experiences in Metaverse by bringing together startups which can offer such services, **tourism department as well as private owners of tourism experiences or museums.**

Digital assets

Over a period, the AR-VR & Metaverse TAC shall envisage to develop a strong knowledge curation as well as dedicated software platforms for making such Metaverse based AR-VR experiences. There shall be relevant physical assets such as Vision Pro or Oculus platforms as well.

Key technology collaborations partners

1. Tourism facility owners (Government & private)
2. VR Headset makers such as **Meta & Apple**
3. Compute platforms such as **NVIDIA Omniverse**

Potential collaboration with emerging startups

1. **Histovery** – AR/VR startup focusing on setting up Historical experiences.
2. Travel NFT Issuers such as **Travala.**

Private sector investments

Once the market for making AR-VR based tourism experiences is developed centred around EMTH, this shall be a strong case for investment from major tourism players such as Thomas Cook or major hotel chains and even technology players digitizing tourist experiences.

Healthcare & Life Sciences

Gen AI | HealthShield I AI for Health

Kerala has a strong practice of community healthcare with one of the most evolved primary healthcare systems in India. It also has a cluster of innovative life-sciences startups. Leveraging that strength and the high internet penetration, Indian language-based Language Models (LLMs) can play a pivotal role in raising awareness about health-related topics, assist hospitals in diagnosis. If an LLM on healthcare in vernacular language is built up with community participation, this could become a valuable asset for startups to innovate.

Gen AI in Healthcare market is estimated currently as $1.9 billion in 2023 and is poised to grow to $22-23 Billion by 2032.

Technological significance for EMTH

Microsoft's recent collaboration with Sarvam AI, an Indian startup specializing in Indic language LLM powered by voice, signifies the evolving landscape of Gen AI. This partnership hints at the potential for a renaissance in language computing, showcasing the growing importance and capabilities of AI-driven linguistic technologies in the modern era.

MedLM is a family of LLM's fine-tuned for the healthcare industry. This was built by Google Research. It was the first AI system to reach human expert level on answering US Medical Licensing Examination (USMLE)-style questions. Currently Google's LLM's are supposed to be used only for diagnosis and not treatment

Envisaged outcomes

The **Gen AI** Technology Advancement Centre (TAC) shall anchor all the initiatives \ aimed towards developing solutions relying on vernacular language LLM's on Healthcare.

Market making

The TAC shall develop markets for solutions centred around LLM for Healthcare. This would involve bringing hospitals, primary health centres, educational institutions, kiosks etc. together. Many applications centred around awareness of health, hygiene, vaccination, first aid etc could be developed with such an LLM. Building a domain specific LLM would require strong community participation, which the Kerala ecosystem is equipped with. Initially markets for **information Kiosks disseminating basic healthcare and hygiene information** as well **as diagnostic assistants for multiple situations** shall be the focus.

Digital assets

The TAC shall develop an LLM through community participation leveraging on which many applications could be built.

Key technology collaborations partners

1. Cloud partners – **AWS, IBM, Microsoft Azure**
2. Hospitals – **Aster, Apollo, Government Medical Colleges**, etc.
3. Insurance players. National AI mission with the compute infrastructure and National Health Mission with its focused approach towards health shall be the other collaboration partners. Similarly, educational institutions, local government organizations etc could also be collaboration partners.

Potential collaboration with emerging startups

1. **Sarvam.AI** – Vernacular language based LLM
2. **Augmedix** – Medical notes from doctor – patient conversations

Private sector investments

Once the markets and the ecosystem around language LLM start functioning well, private players who focus on solutions such as insurance, government organizations, educational institutions, could be roped in to make larger investments.

Healthcare & Life Sciences

Gen AI | CareCompanion I Care Robots for Elderly Care & Active Old Age

With the rapid increase in the elderly population in the world, there is a pressing need for targeted interventions to support the physical and mental well-being of senior citizens. This demographic shift also offers a promising business opportunity for startups focusing on elderly care. In Western nations & Japan, this segment has been served by 'Care Robots' for multiple purposes. Advent of Gen AI has brought back the focus on Care Robots and multiple initiatives to cater to the mental and physical well-being are being tried out in the West.

Indian senior care market is poised to grow from $15 billion in 2021 to $50-$60 billion by 2030.

Technological significance for EMTH

Kerala has an active set of startups working on Robotics. The fusion of Robotics and Gen AI is an area of immense potential for Kerala ecosystem to innovate further. The rising old age population's welfare is a major concern for the state as well.

India's aging people will be around 19 percent of the total population by 2050. According to the UN, the numbers will increase to 193 million by 2031 from 138 million in 2022. By 2050, there will be about 319 million individuals above 60, making India of one the world's largest senior populations, or one elderly person for every five people.

Envisaged outcomes

The **Gen AI** Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards developing startup ecosystem catering to fusion of Robotics and Gen AI.

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Market making

The TAC shall develop markets for solutions centred around usual elderly care problems around Care-Robots for elderly care and well-being. Care Robots shall evolve over a period adapting from basic tasks to providing companionship and emotional care. Such use-cases adapting to a vernacular language base has immense potential for startups in India.

Digital assets

The TAC shall develop a robust LLM based on which such solutions could be hosted and can be selected by various Robotics partners to implement the solutions. Multiple situational responses can be trained on to the model as well engaging trained Geriatric care providers.

Key technology collaborations partners

1. Old age home networks such as **Season-Two ventures**
2. Cloud platforms such as **AWS / Google** for hosting Gen AI models for Care-Robots.
3. Biomedical and Medical devices incubators like **SCTIMST-TIMed**

Potential collaboration with emerging startups

1. **KITES Seniorcare** – Geriatric care startup.
2. **LifeSTech** - Accessibility focused solutions for elderly care
3. Robotics startups in Kerala such as **Asimov Robotics, Sastra Robotics, Ingen Dynamics**

Private sector investments

Once the markets and the ecosystem around old age start functioning well, private players who focus on solutions such as insurance or large hospital chains providing palliative care facilities could be roped in for strategic investments.

Healthcare & Life Sciences

Genomics & AI | Regain Youth I Anti-Aging

Globally, there is increasing research and investment in anti-aging technologies, with numerous startups developing innovative products in response to growing demand. Significant interest and funding are directed towards AI-driven drug discovery and computational models that identify aging-related biomarkers, reflecting strong market growth.

Global anti-aging market is projected to nearly double, reaching approximately ~$160 billion USD from its current ~$80 billion USD.

Technological significance for EMTH

Anti-aging technologies, rooted in genomics and medicine, offering a promising area for EMTH. Developing a data platform dedicated to aging-related physiological and genomic data would open substantial opportunities for startups targeting this space. A key focus will be on ageing biomarkers that reflect biological aging processes, such as cellular senescence and inflammation, and leveraging AI to create drugs that target these biomarkers to potentially slow aging.

Emerging startups in this field, like Insilico Medicine, have shown success, with Insilico reporting positive Phase IIa results for ISM001-055, an AI-designed drug for Idiopathic Pulmonary Fibrosis. Major investors, including Jeff Bezos and Sam Altman, are also investing in companies working on cell reprogramming for anti-aging.

Envisaged outcomes

The **Gen AI & Genomics** Technology Advancement Centre (TAC) will lead initiatives in developing anti-aging tech solutions, creating a support system for startups in this sector.

Market making

The TAC will establish a technological platform encompassing various aspects of aging including physiological, genetic, medicinal, food & nutraceutical data. This comprehensive data layer will be anonymized, ensuring privacy while serving as a foundation for startups working on **aging biomarkers and related drug discovery**. TAC will leverage national AI infrastructure initiatives to support the analytical needs of these startups, fostering the growth of companies/startups similar to Insilico Medicine within Kerala.

Digital assets

TAC will develop a data-driven platform to consolidate aging-related data, serving as a key resource for startups focused on aging biomarkers and drug development.

Key technology collaborations partners

1. Cloud partners – **AWS, IBM, Microsoft Azure**
2. Hospitals – **Aster, Apollo, Government Medical Colleges**, etc.
3. Insurance companies – **Allianz, Star, Bupa**, etc.

As healthcare becomes more interconnected, collaboration with hospitals and insurance providers will support the integration of anti-ageing services.

Potential collaboration with emerging startups

1. **Calico Labs** – Focussed on aging biology and interventions for healthier, longer lives.
2. **Atomwise** - A preclinical pharma company using AI to revolutionize drug discovery.

Private sector investments

As startups from this ecosystem demonstrate potential, insurance companies, hospitals, biotech and pharmaceutical companies, and wellness service providers could be engaged to drive investment in this sector.

Healthcare & Life Sciences

Genomics & Industry Cloud | GenomeGuard - Early Disease Discovery

Genetic data is increasingly used for the early detection of various diseases. Although similar products are already available, they often lack comprehensive disease coverage and are generally not cost-effective. Significant advancements are needed before these solutions become widely accepted, accessible, and affordable for the broader population. Algorithmic development and procedural refinement are essential, and startups play a critical role in driving this transition forward.

Global Genomics market is estimated currently as $45 billion in 2023 and is poised to grow to $83-$85 Billion 2028.

Technological significance for EMTH

Kerala's upcoming Genome Data Centre positions the state competitively to advance in this ecosystem. With a health-conscious population, significant spending capacity, and a well-established healthcare sector that attracts substantial medical tourism, Kerala is well-equipped to become a leader in genetic data applications. Emerging technologies like Neuralink also highlight the potential for breakthroughs in precision healthcare, further strengthening Kerala's role in cutting-edge medical innovation.

Genomics England (GEL) was formally established in July 2013 by National Health Service (NHS) in UK and AWS. GEL was tasked with a flagship project to sequence 100,000 whole genomes from NHS patients with rare diseases and their families, In subsequent stage, NHS has partnered with GEL and the UK Biobank to sequence up to 5 million genomes in 5 years and make the data available for research.

Envisaged outcomes

The **Genomics** Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards developing solutions catered Early disease discovery.

Market making

The TAC shall develop markets for solutions centred around usual early disease discovery. This would involve bringing hospitals, diagnostic centres, and startups together in the area of early disease detection with Genomic data. A key aspect in these solutions is that the startups leveraging the EMTH facilities and network shall use Open APIs and frameworks. The data as well as solutions of one startup can be leveraged by another startup (for a fee).

Digital assets

The TAC shall develop an industry cloud layer on which such solutions could be hosted and can be selected by various partners to implement solutions. The Genome data itself over a period will become a key asset.

Key technology collaborations partners

1. Cloud partners
2. Hospital and diagnostic chains (e.g.: Karkinos Healthcare)
3. Insurance players
4. Biomedical and Medical devices incubators like SCTIMST-TIMed
5. Institute of Advanced Virology

Potential collaboration with emerging startups

1. MedGenome - Genome Data Sequencing & Bioinformatics.
2. MapmyGenome – Early Disease discovery.
3. QuantumCyte - Molecular and Genomic data analysis to detect and treat cancers.

Private sector investments

Once the markets and the ecosystem around Genome Data Centre start functioning well, private players that focus on solutions such as insurance, diagnostic chains or even hospitals could be roped in to make larger investments.

Healthcare & Life Sciences

Communication Technologies | MediLink – Telepresence Surgery

As healthcare continues to advance in connectivity and precision, telepresence surgery has emerged as a transformative application of communication technologies. Through **real-time, high-definition video and remote-controlled surgical equipment, doctors can perform surgeries on patients across distant locations**. The proposed MediLink platform leverages cutting-edge communication technologies to make telepresence surgery accessible, breaking geographic barriers and bringing expert surgical care to underserved regions. Startups specializing in telepresence solutions can collaborate with cloud providers or establish independent platforms to facilitate secure, high-speed surgical connections. MediLink represents a pivotal step in healthcare innovation, merging communication technology with life-saving medical practices.

The global telepresence surgery market, currently estimated at $500 million, is projected to grow exponentially, reaching $5 billion by 2035, as demand for remote healthcare capabilities escalates.

NASA and the Canadian Space Agency (CSA) have successfully tested satellite-enabled remote healthcare for astronauts and isolated Arctic regions, while the European Space Agency's Meteron project demonstrated robotic surgery controlled over LEO satellite networks. Additionally, platforms like Proximie in the U.S. and South Korea's Asan Medical Center are pioneering real-time remote surgeries.

Technological significance for EMTH

Kerala's strong healthcare infrastructure, skilled medical workforce, and high internet penetration create an ideal setting to pioneer telepresence surgery. Expanding beyond traditional telemedicine, Kerala can leverage LEO satellite connectivity to ensure stable, high-speed communication essential for remote surgeries in even the most remote areas, enhancing access to specialized care and reducing regional health disparities.

Envisaged outcomes

The **Communication Technologies Technology Advancement Centre (TAC)** will anchor all initiatives for MediLink telepresence surgery.

Market making

The Communications Tech TAC will build a self-sustaining market for telepresence surgery by connecting telepresence startups, healthcare providers, and government entities. Initially, EMTH will focus on startups providing remote surgical solutions for complex procedures, such as cardiovascular and orthopaedic surgeries, in underserved hospitals and communities.

Digital assets

Over time, the Communications TAC will develop a set of open frameworks, APIs, and telemedicine protocols that can be used for remote surgery. A knowledge aggregation will be fostered within this technology, serving as a resource hub for startups, healthcare institutions, and technology developers.

Key technology collaborations partners

1. ISRO – For leveraging LEO satellite technology and connectivity for remote healthcare applications.
2. Cisco HealthPresence – For secure, high-speed telepresence solutions and expertise in remote surgical network setup.
3. Biomedical and Medical devices incubators like SCTIMST-TIMed

Potential collaboration with emerging startups

1. Tesseract Health – Known for telemedicine tools
2. Sastra Robotics - Developing robotic assistance technologies
3. Proximie (USA) – A telepresence platform for real-time surgical collaboration

Private sector investments

As the market for telepresence surgery grows, major telemedicine companies and cloud providers like Google Health, Cisco HealthPresence, or Philips TeleHealth may see Kerala as a prime location for investment. The state's development of a healthcare-tech ecosystem could also attract global surgical equipment manufacturers, offering strategic investment opportunities in the TAC for MediLink.

Food & Agriculture

Genomics & Industry Cloud | AgriGenome - Agri-Genomics & Microbiomes

The advent of genomics in agriculture has created new possibilities for developing high-yield, disease-resistant crops. Microbiomes, communities of microorganisms within specific environments, combined with genetic analysis, can pave the way for future crops that are both high-yielding and pest-resistant. Establishing an innovation cluster focused on **Agri-genomics and microbiomes** holds significant potential, offering benefits in terms of investment, food security, sustainability, and industry advancement.

Agri-Genomics market is presently estimated to be about 4 $billion and is expected to grow to $6-$7 billion by 2030.

Technological significance for EMTH

Kerala's status as a biodiversity hotspot, combined with the establishment of the upcoming Genome Data Centre, places the state in an advantageous position to develop a high-yield crop ecosystem. While regulatory frameworks are still evolving, there is strong global momentum toward **disease-resistant and high-yield crop development**. The computational analysis required to identify these crop varieties presents a valuable opportunity for EMTH to foster an innovation cluster in this field. Additionally, the emerging nutraceutical market requires substantial computing power and genome sequencing, and Kerala's growing nutraceutical sector could benefit significantly from a genome computing and microbiome technology ecosystem.

As of November 2023, India has only allowed the cultivation and import of one genetically modified organism (GMO), But cotton, a non-food crop. Genetically Modified Mustard strains are under evaluation by multiple health and legal bodies

Envisaged outcomes

The **Genomics** Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards developing solutions centred around **high-yield crops and cultivation methods.**

Market making

A global market where genetic analysis of crops anywhere in the world could be addressed by startups leveraging the Genome Data Centre in EMTH. The more genome sequencing is done, more competitive the ecosystem would become. The Genome sequenced data would be kept as an open asset which any startup associated with EMTH could use. Similarly, the initiatives under Center of Excellence of Microbiome (CoEM) proposed to be established in Life Sciences Park can also add to the market making initiatives. A pilot project could be run to identify **high yield varieties of berries which have high commercial value.**

Digital assets

The TAC shall develop a readily available sequenced genome data over a cloud platform for all the startups to use for a nominal fee.

Key technology collaborations partners

1. Cloud partners
2. Food and agriculture firms globally and in Kerala
3. National AI mission with the compute infrastructure

Potential collaboration with emerging startups

1. Trace Genomics – Genome sequencing of soil for better agro yields.
2. Piatrika Biosystems – High Yield seeds discovery & high yield farming tech
3. Front Range Biosciences - High Yield seeds discovery & high yield farming

Private sector investments

Once the markets and the ecosystem around Genome Data Centre start functioning well, private players who focus on solutions such as nutraceuticals, large farming players from across the world or even niche focused crop centric players (e.g.: wine growers) may see a strong value proposition to invest.

Food & Agriculture

Gen AI | HarvestMind - AI for Agriculture

LLMs (Large Language Models) are rapidly advancing in vernacular language support across India, with the National AI Mission prioritizing datasets and LLMs to benefit the broader population. Given Kerala's focus on comprehensive 'package of practices' in agriculture and fisheries, spanning multiple crops, LLMs could be developed as digital public goods within EMTH. Startups could utilize these **LLMs to create applications such as knowledge kiosks for farming, fisheries, animal husbandry, and sericulture in Malayalam**, potentially funded by crop and fisheries insurance providers.

Gen AI in Agriculture market is estimated currently as $135 million in 2022 and is poised to grow to $1.2-1.5 billion by 2032.

Technological significance for EMTH

The Government of India has launched Bharat-Gen, an initiative aimed at delivering Gen AI models and applications as digital public goods, with a focus on linguistic diversity. Over the next two years, Bharat-Gen plans to develop foundational models and relevant datasets across multiple domains. This initiative provides a strong opportunity for EMTH to collaborate with Bharat-Gen in developing foundational models for agriculture, animal husbandry, fisheries, and sericulture, making these accessible for startups to build transformative applications.

A challenge in the agriculture sector is the lack of qualified agronomists who can provide advice on crop production and protection. Microsoft Research conducted a study that evaluates the performance of LLMs in agro-certification exams in multiple countries. The results show that GPT-4 can achieve high scores on these exams, demonstrating its ability to understand and generate domain-specific knowledge.

Envisaged outcomes

The **Gen AI** Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards developing solutions relying on vernacular language LLM's on Agriculture, fisheries, sericulture, and livestock to **disseminate scientific knowledge through kiosks or mobile apps.**

Market making

The TAC shall develop markets for solutions centred around LLM for Agriculture. This would involve bringing farmers, FPO's, educational institutions, kiosks etc together. Many applications centred around awareness of agriculture, fisheries, sericulture, etc could be developed with such an LLM. Building a domain specific LLM would require strong community participation, which the Kerala ecosystem is equipped to do. Organizations such as ICFOSS could be tasked with developing such community efforts. The TAC shall work closely with the Bharat Gen initiative.

Digital assets

The TAC shall develop an LLM through community participation leveraging on which many applications could be built.

Key technology collaborations partners

1. Cloud partners
2. FPO's
3. Startups such as **Farmers Fresh, Ninjacart** etc.
4. National AI mission with the compute infrastructure shall be the other collaboration partner. Similarly, educational institutions, local government organizations etc could also be potential collaboration partners.

Potential collaboration with emerging startups

1. **Agmatix** – Insights from agro-Data, Digital Crop Advisor
2. **Sarvam.AI** – Indic Language LLM's
3. **Gnani.AI** - Voice based AI platform.

Private sector investments

Once the markets and the ecosystem around language LLM start functioning well, private players who focus on solutions such as FPO's, government organizations, educational institutions, Food, and agriculture firms could be roped in to make larger investments.

Food & Agriculture

Industry Cloud, Sensors & IOT | FarmTech Stack - Crop Specific Farming Stack

As the ESG, Net-Zero consciousness gains mainstream adoption, more and more individuals are taking up farming activities. The technologies that aid farming – be it precision agriculture or crop-specific nutrients or marketing solutions – all are quite disparate. There is a strong opportunity for startups to make **crop-specific farming stack** for better yields and care and marketing the same.

Global agro-tech market is estimated currently as $23 billion in 2022 and is poised to grow to $75-85 Billion by 2030.

Technological significance for EMTH

Kerala is a state where land & labour is costly, people are environmentally conscious and have a strong inclination towards fresh farm produce. The state is aggregating land parcels to encourage agriculture. For this to work effectively, technology aided stack covering various aspects of farming such as automation, precision irrigation & monitoring is essential.

Kerala Startup Mission (KSUM)-supported uFarms.io has implemented its IoT farm automation system with Uptown Urban Farms Pvt Ltd to set up the state's first and biggest automated hydroponic farm in Trivandrum in 2023.

Envisaged outcomes

The Industry Cloud and Sensors & IoT Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards curating **crop specific farming stacks.**

Market making

The TAC shall develop markets for solutions centred around farming stack. These could mean creating a set of startups which can offer these farm-tech interventions as a service or create an ONDC layer-based solution through which farmers can list their items for sale, or create a GIS tagged identifier for these crops. Such solutions could be offered through an industry cloud marketplace. **As a pilot to start with, such stacks could be developed for high value products such as berries.**

Digital assets

The knowledge curation on the different types of sensors and IoT would become a valuable asset for EMTH. Eventually, the sensor & IoT lab in which many such sensors would be tested by startups in various aspects would become a strong physical lab. The software solutions being developed leveraging EMTH frameworks would require having open APIs and frameworks, which could be used by startups for a fee.

Key technology collaborations partners

1. Cloud partners such as **Cropin**
2. Sensors & IoT making firms – **KaaloT Technologies, Digital Matter**, etc,
3. State and Central agricultural universities.

Potential collaboration with emerging startups

1. **V-Greens** – Automated vertical farms focussed on Strawberry.
2. **Deep Blue Greens** - Electrostatic interventions for high yield indoor farms
3. **Farmers Fresh Zone** – Farm to consumer Agro-tech startup in Kerala

Private sector investments

Once the markets and the ecosystem farming stack start functioning well, private players who focus on solutions such as logistics, agro products, retailers could be roped in to make larger investments. Investment interest could be generated from industry cloud players or even hardware manufacturers.

Energy

Industry Cloud | Energy Communities

Energy communities are small agglomerations in the vicinity of a sub-station that has both demand and supply resources. The idea is that if more energy is generated locally, there would be minimum transmission & distribution loss. Across the World, different types of technologies are being tried out to implement varied models of energy communities. The most sophisticated models allow consumers to choose from whom they are buying energy, leading to a highly sophisticated model of peer-to-peer energy exchange. EMTH shall work towards enabling technology solutions for **decentralized energy as well as peer-to-peer energy exchange.**

The global decentralized energy generation market size was valued at USD 260 billion in 2022 and is projected to hit USD 920 billion by 2032, growing at a CAGR of ~13%.

Technological significance for EMTH

Kerala is a leader in cutting transmission and distribution loss (7.69% at state level vs national figure of 16.4%). It can further be minimized to reach developed world standards of less than 3% of practices such as energy communities and peer-to-peer energy exchanges are adopted. Startups and innovation ecosystems have a large role to play in such initiatives. The base needed for energy communities and peer to peer energy exchange is an industry cloud platform into which producers & consumers can connect to and function as a market to procure power-supply.

Brooklyn Microgrid project has set up an energy trading community in Brooklyn collaborating with Siemens and Lo3 energy – an energy tech startup

Envisaged outcomes

The **Industry Cloud** Technology Advancement Centre (TAC) shall anchor all the initiatives for Energy Communities. This needs active collaboration from the Grid Operator, including for giving pilot locations to test it out.

Market making

Industry Cloud TAC shall develop a market for applications that energy community can adopt to, which can help the producers to supply the power, consumers to buy it and shows the T&D losses, ESG footprint etc. In a post energy communities world, market value of power is not just dependent on cost of generation, but also on the distance for transmission and distribution. The TAC shall work on startups & innovative solutions towards enabling **decentralized energy and peer-to-peer power exchange. It shall work with KSEB to adopt a pilot location to build a self-sufficient energy community to begin with**

Digital assets

The software layer curated by industry cloud TAC shall be the enabling digital foundation on which startups can build their applications. A classic example is "PicloFlex" which operates a cloud solution allowing citizens and small business units to plug in storage and generation assets into the grid in a flexible manner.

Key technology collaborations partners

1. Open-Source initiatives such as **Energy Web, Grid Singularity**
2. Cloud platforms such as **PicloFlex**.
3. State run initiatives such as **Energy Management Centre**

Potential collaboration with emerging startups

1. **Power Ledger** – Blockchain Enabled Energy trading solution.
2. **Hamaragrid** - Setting up Microgrids based on renewable energy.

Private sector investments

Once the market for energy communities and peer to peer energy exchanges are developed around EMTH, this shall be a strong case for investment from energy grid players such as **Siemens, Schneider Electric & ABB.**

Energy

Energy Management & Optimization | EcoOptimize - Energy Optimization

A lot of the devices used at present need to be redesigned for better energy efficiency. Similarly, there are a lot of optimizations that need to be done at the stage of generation (e.g.: solar panels), storage (distributed storage - vehicle to grid) as well as consumption. There are many existing startups in Kerala that have solutions for optimizing generation (Solyield) and consumption (Greenie). This nascent innovation cluster has great potential to develop into an energy optimization tech ecosystem. EMTH shall work toward innovative solutions on optimization for **solar energy, generation vehicle to grid tech, identifying and fixing energy leakages.**

It is estimated that 66% of the primary energy used to create electricity is wasted by the time the electricity arrives at the customer meter even in developed markets.

Technological significance for EMTH

Reaching the net-zero targets need optimizing energy usage across generation, transmission, storage & consumption. Kerala already has a cluster of innovative energy-tech startups. EMTH could work with these startups to develop the innovation ecosystem. Kerala has made strategic investments in Graphene, which is supposed to be a game changing material in consumption and generation of energy. The focus on Energy Optimization will be an augmented focus on that existing investment.

In India, 20-30% of electricity is estimated to be wasted in homes due to inefficient devices and wiring.

Rice University researchers have found ways to harvest Hydrogen and Graphene from Plastic waste at low cost.

Envisaged outcomes

The **Energy Management & Optimization** Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards Energy Optimization. This application requires collaboration with the Grid Operators.

Market making

Energy Management & Optimization TAC shall develop a market for applications that have solutions aimed towards optimizing energy usage. These could involve **optimization solutions marketed at Solar Power generators, developing markets for vehicle to grid (V2G) solutions, identifying and fixing energy leakages.**

Digital assets

The TAC shall develop a marketplace for such startup solutions which could be used by people across the state connected to the grid. These applications shall use Open API's and frameworks so that other startups can also leverage the same for a fee. There shall be a strong knowledge aggregation on how to work with electricity grid. This TAC shall work in close coordination with Energy Management Centre and Graphene CoE, which are distinct initiatives by Kerala. Government

Key technology collaborations partners

1. Grid Operators such as KSEB
2. Local Electrical equipment makers such as V-Guard
3. Battery swapping solutions such as Sun Mobility

Potential collaboration with emerging startups

1. Solyield - Solar power generation optimization
2. Greenie – Energy Monitoring & Management for Buildings
3. Viritech – Hydrogen Power train for automotive solutions using graphene.
4. Startups such as ChargeMod (EV charging), Sheru.se (distributed storage)

Private sector investments

Once there are enough energy optimization tech related startups in the EMTH, investment could be generated into the TAC by relevant energy technology companies such as Siemens, Schneider Electric etc as well as various ESG funds.

Energy

Energy Management & Optimization | Hydrogen Valley

A hydrogen valley is essentially an ecosystem, typically funded by local, national, and international funds, that clusters various industrial and research initiatives to conduct pilot projects across the entire hydrogen value chain – from production and transport to distribution, and end-use, sometimes including storage. Its goal is to enhance the economics of hydrogen as an energy source through appropriate policies and incentives.

Global Hydrogen market is poised to grow from USD 240 billion in 2023 to USD 440 billion by 2031, growing at a CAGR of 7 - 8%.

Technological significance for EMTH

Kerala has significant potential to become an emerging production hub for Hydrogen. As production technologies advance of Hydrogen evolves technologies advance, producing hydrogen from freshwater is expected to become more viable. The availability of abundant freshwater resources as well as proximity to international shipping routes positions it well for exporting has potential to position Kerala as a vital node in the Global Hydrogen Economy. Recognizing this potential, NASDAQ-listed Renew has announced a major investment in green hydrogen generation in Trivandrum.

The initial outlay for the National Green Hydrogen Mission will be ₹ 19,744 crores, including an outlay of ₹ 17,490 crores for the SIGHT (Strategic Interventions for Green Hydrogen Transition) programme, ₹ 1,466 crore for pilot projects, ₹ 400 crore for R&D, and ₹ 388 crore towards other Mission components.

Envisaged outcomes

The **Energy Management & Optimization** Technology Advancement Centre (TAC) shall anchor all the initiatives aimed towards developing Hydrogen Valley.

Market making

The TAC shall focus on storage and consumption side rather than generation. Hydrogen generation is a crowded space with many initiatives across the world already happening and is largely corporatized. Hence from a startup perspective, opportunity lies mostly in the consumption side. The TAC shall develop a cluster of startups which can use **Hydrogen as a fuel for various needs, especially maritime. and trucking sectors.**

Digital assets

The TAC shall develop a marketplace for such startup solutions focused on Hydrogen as a fuel. This could be used by anyone who may want to move into Hydrogen as a clean fuel source.

Key technology collaborations partners

1. Local Electrical equipment makers such as **V-Guard**
2. Truck makers such as **Ashok Leyland** – Long distance trucks are a place where Hydrogen as a fuel source is expected to make an impact.

Potential collaboration with emerging startups

1. **Voyex** – Liquid Hydrogen Carrier Technology – maritime, trucking sector
2. **LyteAviation** – Hydrogen powered eVTOLs.
4. **Hygn** – Hydrogen Fuel Adapters for Diesel Engines
3. **Fly-Box** - Maritime freight transportation solutions based on Hydrogen.
4. **Keyou** – Reengineering Deisel Engines to operate on Hydrogen.

Private Sector Investments

Once there are enough Hydrogen related startups in the EMTH, investment could be generated into the TAC by companies such as Renew and Adani Energy or Reliance Energy. Strategic investment could be sought from companies such as GAIL as well.

7.
Financial Assessment Summary

Financial feasibility

The financial assessment considers the construction of the EMTH building with a G+5 structure with a basement, based on dimensions similar to the nearby Digital Sciences Park. Each floor could potentially offer 66,613 sq. ft. of space. The analysis explores two operational scenarios for the above-ground floors: a furnished layout for co-working and laboratory use, or a warm shell configuration for leasing or sale. Initial projections estimate an Internal Rate of Return (IRR) of 11.3% and a payback period of approximately 14 years. These figures may vary based on factors like floor count, rental/sale strategies, and investments in infrastructure such as laboratories. In a private sector context, operating the facility for 25 years yields an estimated IRR of about 10.3%. This IRR may necessitate Viability Gap Funding (VGF), given private sector cost of capital considerations. The accuracy of these projections will be enhanced through detailed engineering assessments and soil testing, crucial for precise financial planning and decision-making.

Total project cost

INR 250 Cr

Infrastructure timeline

3 Years

Internal rate of return

11.3%

Payback period

14 Years

Project funding

- **State Government Equity:** 3% (Proportional to Land Value)
- **External Financing:** INR 243 Crore

Revenue streams

- **Office Space Rental:** Lease office spaces to startups and corporates operating in the identified sectors or technologies.
- **Corporate Innovation Programs:** Generate revenue through corporate innovation programs focused on these sectors.
- **CSR Programs:** Run CSR programs in the targeted sectors and technologies.
- **Stake in Startups:** Acquire a nominal stake in supported startups and generate revenue by selling these stakes at opportune moments.

Financing options

Three levels of funding are being considered for EMTH.

1. Infrastructure funding (Public)

A discounted financing scheme from NABARD, with a cost of capital of 5.25%, a moratorium period of 2 years, and a repayment period of 7 years, is being evaluated as the primary funding source. While this public funding offers a highly favourable rate, if the route chosen is public funding, it represents a significant financing avenue. It is important to note that, since it involves public money, the selection process for firms would need to adhere to government procedures, which may require careful consideration given the aggressive timelines set by the Kerala Startup Mission.

2. Infrastructure investment (Private)

To attract private investment for infrastructure, a competitive transaction advisory process must be executed. The various methods of transaction advisory schemes are detailed in the financing model section. Private sector involvement has the potential to accelerate construction through a focus on efficiency and revenue generation. However, EMTH's objective extends beyond profit maximization; it aims to foster a supportive environment for the growth of the entire startup ecosystem. Therefore, while collaboration with the private sector is essential, it is crucial to maintain a balanced approach in which the design and operation of the building align with the overarching goals of the startup ecosystem, rather than prioritizing rental income alone.

3. Opex Funding (Grants / Mission Schemes etc.)

Under each TAC, there are many opportunities to tap into various programs of the Government of India, such as the National AI mission, National Green Hydrogen Mission, INSPACE etc. These could be leveraged for operational funding. Once the market-making initiatives discussed under each TAC gain momentum, based on alignment and traction, EMTH can pursue funding from these national-level programs.

Financing models

Several financing models are being considered for the construction and development of the EMTH building and infrastructure, encompassing both public and public-private partnership (PPP) frameworks. Selecting the appropriate financing model, operationalizing it, and engaging a private developer requires a transaction advisory process, beyond the scope of the current assignment. This may involve conducting an Expression of Interest (EOI) process and multiple discussions with potential developers before initiating a Request for Proposal (RFP) process to select a developer. These options are outlined as follows:

Payback \ Return on Investment	LOW	MEDIUM	HIGH
LOW	Public Funded	DBFOT	DBFOT
MEDIUM	Public funded infra/ Annuity.	DBFOT with VGF	DBFOT with Revenue Share
HIGH	Annuity Model	DBFOT with VGF	DBFOT with Revenue Share

Figure 5. Financing Model Matrix

8.

Action Plan for Operationalizing EMTH

Governance & management

Organization Structure

The institutional structure for implementing EMTH comprises three key levels: the Strategic Oversight Committee, the Project Steering Committee, and the Project Management Team (PMT). Each level plays a crucial role in overseeing and managing different aspects of the project, ensuring alignment with EMTH's vision, mission, and objectives. The Execution team shall report to their respective leads of **Infrastructure, Markets & Partnerships, Innovation/Startups & Investments**, who in turn shall report to the Program Director or CEO-EMTH, ensuring effective implementation.

Figure 6: EMTH Organisation structure

Roles and Responsibilities – Governance Committees

Name	Role	Responsibilities
Strategic Oversight Committee	Provide high-level guidance and strategic direction for the EMTH project	• Define the overarching vision and objectives. • Review and approve major project decisions. • Ensure alignment of project activities with organizational goals and priorities. • Provide support and advocacy for the project at the executive level. • Monitor risks, progress, and performance against strategic objectives.
Project Steering Committee	Oversee the overall progress and alignment of the project with strategic goals	• Develop and maintain the project charter, including scope, objectives, and deliverables. • Establish project governance structures, policies, and procedures.

Name	Role	Responsibilities
		• Review and approve project & resource plans • Identify and mitigate risks and issues affecting project delivery. • Provide guidance and direction to the Project Management Team (PMT) based on strategic objectives
Project Management Team (PMT)	Execute day to day activities with respect to the Emerging Tech Hub project initiation and implementation.	• Develop detailed project plans, schedules, and work breakdown structures. • Allocate resources, assign tasks, and track progress against project timelines. • Coordinate and communicate with internal and external stakeholders. • Implement change management processes. • Ensure quality control and compliance with project requirements and standards

Table 5.Roles and Responsibilities – Governance Committees

Roles & Responsibilities – Project Management Team

The Project Management Team (PMT) will play a pivotal role in executing day-to-day activities and tasks to achieve project objectives. They will develop detailed project plans, schedules, and work breakdown structures, ensuring clarity and alignment across all phases. The PMT shall allocate resources effectively, assign tasks to team members, and diligently track progress against established timelines to maintain project momentum. Coordination and communication with internal and external stakeholders will be paramount, facilitating seamless collaboration. Additionally, the PMT will implement robust change management processes to adapt to evolving project needs.

Position Name	Role	Responsibilities
Program Director/ CEO – EMTH	Overall, in charge of the entire EMTH Program	• Strategize the EMTH program. • Undertake External Stakeholder interactions. • Successfully execute the EMTH program
Infrastructure Lead	In charge of the physical infrastructure implementation	• Ensure that the infrastructure plans are approved, and construction is managed as per the schedule. • Manage the relationship with co-developers / engineering firms. • Oversee the necessary procurement as per the Government norms
Innovation/Startups Lead	Anchor various initiatives under TAC	• Run market-making programs under each TAC. • Manage the aggregation of digital assets, collaborations etc so that the overall value proposition of TAC & EMTH is increased. • Design & execute outreach programs to develop markets and manage the aggregation of knowledge in technologies. • Run corporate innovation programs. • Engagement of Startups and other stakeholders

Position Name	Role	Responsibilities
		to facilitate pilot projects • Manage the sandboxes / labs under the TAC • Support the TAC manager for various initiatives under TAC
Markets & Partnerships Lead	Sector-focused outreach and in charge of outreach towards startups both inside & outside Kerala	• Develop corporate engagements in EMTH. • Market EMTH as a destination for corporate innovation needs & bring in more business. • Market EMTH as a destination for innovation among startup communities within & outside the state • Approach high-potential startups to engage & come to EMTH
Investments Lead	Bring in investments and for-profit commercialization models to EMTH	• Promote the investment potential of TACs, develop market-making programs as investment vehicles. • Approach HNIs, Diaspora, Venture funds, and Angel investors to develop the investment ecosystem. • Support commercialization of IPs of startups • Responsible for increasing the valuation of EMTH as a whole

Table 6. Roles & Responsibilities – Project Management Team

Risk Management

EMTH must remain vigilant of potential risks that could impact its operations and objectives as it endeavours to promote innovation and drive technological advancements. This includes financial risk, technology risk, market risk, people risk, economic risk, and operational risk, all of which have been identified along with the applicable mitigation strategies.

Risk Category	Risk	Risk Mitigation
Financial Risk	• EMTH faces the risk of financial escalations, potential delays in realizing grants or loans, which could hinder timely project execution.	• Start program implementation without waiting for complete infrastructure readiness to generate initial success and attract more funding sources. • Success in program execution will demonstrate viability and attract diverse funding streams, reducing dependency on specific sources. • Further, diversify funding sources, maintain a robust financial management system, and establish contingency plans for budget shortfalls.

Risk Category	Risk	Risk Mitigation
Technology Risk	• The ever-evolving nature of technology poses a risk to EMTH, as advancements or disruptions can impact ongoing projects and operations. • EMTH is vulnerable to cybersecurity threats such as data breaches, malware attacks, or system vulnerabilities, compromising sensitive information and operations.	• Implement Trigger-2 technology (convergence) with a low likelihood of significant disruptions. • In the event of any disruptions, EMTH TAC can reorient itself towards an alternative strategy or stream. • Stay updated with technological trends, invest in adaptable and scalable solutions, and foster partnerships with tech experts for continuous innovation. • Implement robust cybersecurity measures, conduct regular vulnerability assessments, train employees on cybersecurity best practices, and have incident response protocols in place.
Market Risk	• EMTH relies on market acceptability and the willingness of startups to divest equity, which can fluctuate based on market conditions and sector slowdowns. • EMTH operates in sectors with evolving regulations, compliance requirements, and legal uncertainties, affecting business operations and strategies.	• Initiate multiple programs under each TAC without waiting for full infrastructure readiness, diversifying risk exposure. • Ensure successful program execution to build credibility and reduce market risk, attracting more participants and stakeholders. • Stay updated with regulatory changes, engage legal advisors, conduct compliance audits, and proactively adapt to regulatory developments.
People Risk	• Effective execution of EMTH initiatives requires a focused and skilled team. The absence of such a team can lead to project delays and inefficiencies. • EMTH may face challenges in finding skilled professionals with specialized expertise required for projects or operations.	• Establish a strong second line of command to ensure continuity and effective project management. • Engage interns from reputable business schools to infuse fresh talent, perspectives, and energy into the team, enhancing execution capabilities. • Implement retention strategies, offer competitive compensation and benefits, provide opportunities for

Risk Category	Risk	Risk Mitigation
	• EMTH may experience turnover or attrition of key personnel, leading to knowledge gaps, project delays, and loss of productivity.	career growth and development, and cultivate a positive work culture
Economic Risk and Slowdown	• A slowdown in the economy can impact EMTH's funding, investor interest, and overall project viability.	• Focus on sectors with low macroeconomic dependency such as healthcare & life sciences, space, and agriculture, reducing sensitivity to economic downturns. • Target long-term investors with a strategic view, aligning with EMTH's goals and mitigating short-term economic fluctuations' impact on funding stability.
Operational Risk	• EMTH may face disruptions in the supply chain, such as delays in receiving necessary equipment or materials, which could impact project timelines.	• Diversify suppliers, maintain buffer stock for critical items, establish alternative sourcing options, and monitor supply chain performance regularly.

Table 7. Risk Management

Implementation action plan

The implementation of the Emerging Tech Hub requires a structured approach to ensure smooth execution and sustainable growth. This action plan outlines key activities and guidelines for navigating through diverse work streams crucial to the hub's success. The work streams below are not necessarily sequential; for instance, Infrastructure Development continues throughout. These activities are broadly sequenced in accordance with the EMTH operating model framework provided in section 5, namely: (i) Set Up Base, (ii) Pilot, and (iii) Scale Up.

Phase	Activities	Description	Responsible Teams	Guidelines
Project Initiation		Initiate the project and lay the groundwork for setting up the Emerging Tech Hub.	Project Management Team, Steering Committee	Project Strategy & Impact Report
Project Initiation	**Infrastructure Development**	Plan and execute physical infrastructure projects to support technological advancements and	Infrastructure Team	DPR/PMC for EMTH Infrastructure facility development

Phase	Activities	Description	Responsible Teams	Guidelines
		operational needs across all stages.		
Set-up Base	**Launch Market Making Initiatives under TACs**	Establish Technology Advancement Centres (TACs) Research and evaluate technologies & Assess applicability to hub objectives. Initiate market-making activities to attract startups in the chosen emerging technologies.	Project Management Team, Markets & Partnerships Team	SOP for Market Making Initiatives
Set-up Base	**Form Foundational Partnerships**	Identify and form partnerships with industry partners, academic institutions, and government agencies to support initial project setups and curate digital assets for EMTH in the long run	Markets & Partnerships Team, Finance, and Investment Team	Partnership Agreement Templates, MoUs
Pilot	**Make Strategic Investments / Grants**	Identify and invest in promising startups or projects aligned with the tech hub's focus areas to stimulate growth and innovation within the ecosystem as well as build digital assets in the long run	Finance and Investment Team	Investment Criteria Guidelines, Due Diligence Checklist
Pilot	**Incubate Startup Clusters**	Provide tailored support and resources to nurture early-stage startups in the chosen TACs & sectors, facilitating their growth and scalability.	Innovation/Startups Team	Startup Onboarding Checklist, Incubation Program Guidelines
Pilot	**Engage with Anchor Corporates**	Collaborate with established corporations to drive synergies, mentorship, and potential investment opportunities	Markets & Partnerships Team, Investments Team, Innovation/Startups Team (TACs)	Corporate Partnership Guidelines

Phase	Activities	Description	Responsible Teams	Guidelines
		for startups and tech initiatives.		
Pilot	**Knowledge Aggregation**	Gather and analyse sector-specific data, technology know-how, and insights to facilitate strategic decision-making of startups and enhance the tech hub's value proposition.	Innovation/Startups Team (TACs)	Data Collection Protocols, Market Analysis Templates
Pilot	**Develop Innovation Sandboxes**	Create controlled environments for testing and validating new technologies, facilitating rapid prototyping and innovation in a risk-free setting.	Innovation/Startups Team (TACs), Infrastructure Team	Sandbox Setup Guidelines, Innovation Process Framework
Scale-up	**Global Positioning of TACs**	Promote TACs as global hubs of innovation and technology excellence, attracting international partners, investors, and talent to enhance global reach and impact.	Markets & Partnerships Team	Marketing Strategy Plan, International Partnership Agreements
Scale-up	**Securing Funding**	Establish funding mechanisms and partnerships with corporate venture funds to support scaling ventures and innovative projects within the tech hub's ecosystem. Establish funding mechanisms and partnerships with corporate venture funds & HNI's to support scaling ventures	Investments Team	Investment Vehicle Structures, Fundraising Guidelines
Scale-up	**Develop Global Networks**	Cultivate strategic relationships with global stakeholders, diaspora, including universities, tech giants, and innovation hubs, to	Markets & Partnerships Team	

Phase	Activities	Description	Responsible Teams	Guidelines
		strengthen collaboration and knowledge exchange.		
Scale-up	**Establish Specialized Investment Vehicles**	Set up entities or funds dedicated to investing in tech startups and high-potential projects, facilitating structured financing and growth opportunities and return potential for investors	Investments Team	Investment Vehicle Documentation, Fund Management Guidelines

Table 8: Phase- wise implementation action plan

The EMTH project is conceptualised at a crucial juncture in Kerala's economic growth trajectory. Historically,

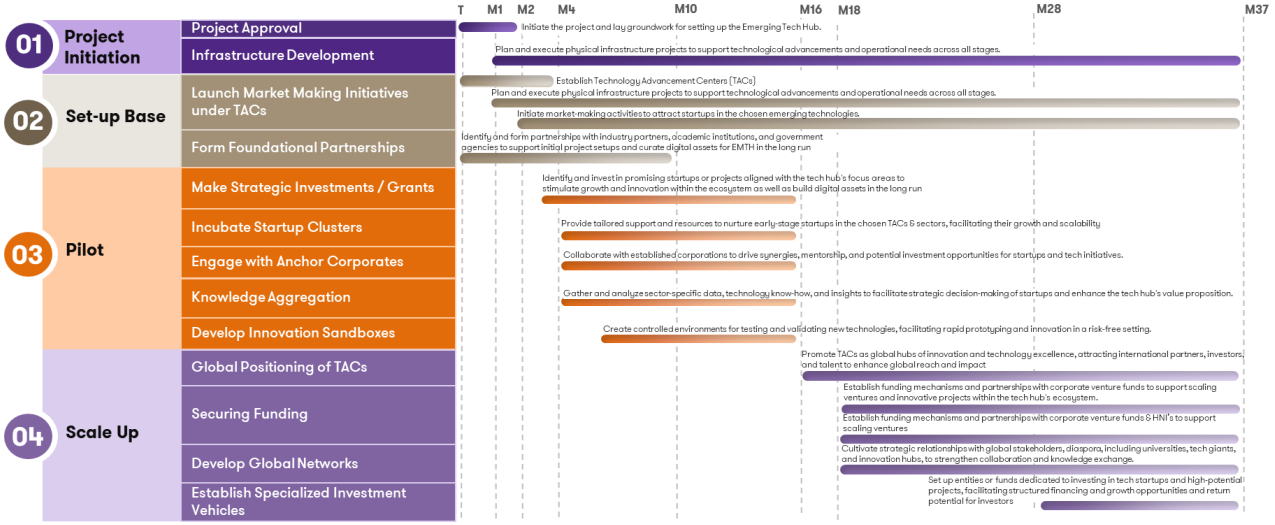

Figure 7: EMTH Implementation plan – Timeline [T (Start of project), Months (M1, M2, etc.)]

the state has invested significantly in education and citizen welfare. However, with white-collar employment in India largely concentrated in urban metropolises, Kerala faces substantial migration of highly skilled youth to other parts of India and abroad. Initiatives like EMTH aim to foster the innovation ecosystem within the state, positioning Kerala at the forefront of emerging technologies. This strategic move is intended to attract a significant portion of the knowledge-based industry's highly skilled employment to the state.

Similarly, in the past decade, several states have endeavoured to cultivate their startup ecosystems through various means. Traditional support mechanisms such as grants, seed investments, incubators, and accelerators are now considered essential rather than offering a competitive advantage to any startup ecosystem. EMTH represents an initiative aimed at creating a distinctive value proposition for the startup and innovation ecosystem in Kerala.

Glossary

5G	5th Generation
6G	6th Generation
AAAA	Addis Ababa Action Agenda
API	Application programming interface
AR	Augmented Reality
ASAP	Additional Skill Acquisition Program
ASI	Artificial Superintelligence
AVGC	Animation, Visual Effects, Gaming, Comics
AWS	Amazon Web Services
B2B	Business-to-Business
BMI	Brain-Machin Interface
CAGR	Compounded Annual Growth Rate
CEO	Chief executive officer
CHIPS	Creating Helpful Incentives to Produce Semiconductors
CSR	Corporate Social Responsibility
DAC	Development of Advanced Computing
DNA	Deoxyribonucleic acid
DPR	Detailed Project Report
EMTH	Emerging Technology Hub
ESA	European Space Agency
ESG	Environmental, Social and Governance
EU	European Union
EV	Electric Vehicle
G20	Group of Twenty
GC	Gaming, Comics
GCC	Global Capability Centres
GDPR	General Data Protection Regulation
GEL	Genomics England
GMO	Genetically modified organism
GPT	Generative Pre-Trained Transformers
GT	Grant Thornton
HAP	High Altitude platforms
LIDAR	Light Detection and Ranging
LLM	Large Language Model
LLP	Limited Liability Partnership
LM	Language Model
LPWA	Low Power Wide Area
MIT	Massachusetts Institute of Technology
ML	Machine Learning
MPET	Mission on Power Electronics Technology
MSME	Micro, Small & Medium Enterprises
NABARD	National Bank For Agriculture And Rural Development.
NASDAQ	National Association of Securities Dealers Automated Quotations
NB	Narrowband
NFC	Near-Field Communication
NFT	Non-Fungible Token
NGS	Next-generation sequencing
NHS	National Health Service
NSE	National Stock Exchange
ONDC	Open Network for Digital Commerce
PCR	Polymerase chain reaction
PDP	Personal Data Protection
PMC	Project Management Consultancy
PMT	Project Management Team
POC	Proof of Concept
PSU	Public Sector Undertaking
RIS	Reconfigurable Intelligent Surfaces
RNA	Ribonucleic acid
SAAS	Software as a service
SAF	sustainable aviation fuels
SDG	Sustainable Development Goals
SIGHT	Strategic Interventions for Green Hydrogen Transition
SOP	Standard operating procedure
SPQC	Smart Power Quality Centre

HAPS	High Altitude platforms stations	**SSL**	Self-supervised learning
HCAI	Human-Centred Artificial Intelligence	**TAC**	Tech Advancement Centres
HNI	High net-worth individual	**TRL**	Technology Readiness Levels
IEDC	Innovation and Entrepreneurship Development Centre	**UK**	United Kingdom
INR	Indian Rupee	**UN**	United Nations
INSPACE	Indian National Space Promotion and Authorization Centre	**UPI**	Unified Payments Interface
IOT	Internet of Things	**US**	United States
IP	Internet Protocol	**USD**	United States dollar
IRR	Internal rate of return	**USMLE**	US Medical Licensing Examination
ITI	Industrial Training Institute	**VC**	Venture capital
IV	Investment Vehicle	**VR**	Virtual Reality
KSUM	Kerala Startup Mission	**WEF**	World Economic Forum
LEO	Low Earth Orbit		

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Annexures

Annexure 1: List of emerging technologies assessed

Emerging Technologies from a number of sources are assessed and those are given below:

Sl. No.	Categorization	Technology	Description	Sources	Tech Readiness Level
1	Security & Privacy	Human Centred AI	Human-Centred Artificial Intelligence (HCAI) system aims to understand human language, emotions, and behaviour, which can help bridge the gap between machines and humans.	Gartner 2024	Close to Market (7-9)
2	Security & Privacy	Behavioural AI	AI-powered behavioural analysis leverages artificial intelligence to learn and predict adversarial behaviour patterns.	Gartner 2024	Close to Market (7-9)
3	Security & Privacy	Responsible AI	Responsible AI is an approach to developing and deploying artificial intelligence (AI) from both an ethical and legal point of view	Gartner 2024	Close to Market (7-9)
4	Security & Privacy	Decentralized Identity	Decentralized identity is an approach to identify and authenticate users and entities without a centralized authority.	Gartner 2024	Close to Market (7-9)
5	Security & Privacy	Ethical AI	Ethical AI is artificial intelligence that adheres to well-defined ethical guidelines regarding fundamental values, including such things as individual rights, privacy, non-discrimination, and non-manipulation.	Gartner 2024	Emerging (4-6)
6	Security & Privacy	Homomorphic Encryption	AI on encrypted data.	WEF 2024	Emerging (4-6)
7	Security & Privacy	Continuous Threat Management	Threat management along with operations	Gartner 2024	Close to Market (7-9)
8	Genomics & Cellular tech	Engineered bacteria in SAF	Recent engineered microorganisms show promise for sustainable fuels, but scalability and supply, at less than 1%, remain challenges.	EU 'Eyes on Future'	Close to Market (7-9)
9	Genomics & Cellular Tech	Alternative livestock	Engineered livestock	WEF 2024	Emerging (4-6)
10	Genomics & Cellular Tech	Advanced Treatments & Transplants	Genomic and cellular analysis enabled treatment and transplants	WEF 2024, MIT Tech Review, Stanford Emerging	Emerging (4-6)

Sl. No.	Categorization	Technology	Description	Sources	Tech Readiness Level
				Tech	
11	Genomics & Cellular Tech	Spatial Omics	Spatial omics is a broad term that refers to spatially resolved molecular technologies designed for the analysis of biological molecules in their native location within a tissue.	EU Eyes on Future	Novel (1-3)
12	Genomics & Cellular Tech	Xenobots with human cells	Scientists developed self-assembling "anthrobots" from human cells to repair neural tissue, surpassing xenobots. These AI-enhanced robots show therapeutic potential and avoid lengthy clinical trials.	EU Eyes on Future	Novel (1-3)
13	Genomics & Cellular Tech	DNA Nanobots	Scientists developed self-assembling "anthrobots" from human cells to repair neural tissue, surpassing xenobots. These AI-enhanced robots show therapeutic potential and avoid lengthy clinical trials.	EU Eyes on Future	Novel (1-3)
14	Genomics & Cellular Tech	DNA Traceability for food	DNA traceability ensures product integrity in supply chains, using DNA extraction or synthetic DNA. Techniques like PCR and NGS provide detailed, scalable tracking superior to traditional methods, advancing food authenticity and compliance.	EU Eyes on Future	Novel (1-3)
15	Genomics & Cellular Tech	Bio-foundries	Tech platforms in different types of laboratories focused solely on accelerating and prototyping biological designs for engineering-biology applications.	EU Eyes on Future	Novel (1-3)
16	Genomics & Cellular Tech	Bio-Robots	Bio robotics is an interdisciplinary science that combines the fields of biomedical engineering, cybernetics, and robotics to develop new technologies that integrate biology with mechanical systems to develop more efficient communication, alter genetic information, and create machines that imitate biological system	EU Eyes on Future	Novel (1-3)
17	Industry Cloud	Platform engineering,	Engineering models centred around creating SAAS platforms	Gartner 2023,24	Closer to market (7-9)
18	Industry Cloud	Domain specific SAAS models	SAAS models built for specific industry domains	Gartner 2023,2024	Closer to market (7-9)
19	Gen AI	AI Augmented development	Develops tools augmented by Gen AI	Gartner 2024	Closer to market (7-9)
20	Gen AI	Machine	ML models mimicking real world	Gartner	Closer to

Sl. No.	Categorization	Technology	Description	Sources	Tech Readiness Level
		customers	customers	2024	market (7-9)
21	Gen AI	Self supervised learning	Self-supervised learning (SSL) is a paradigm in machine learning where a model is trained on a task using the data itself to generate supervisory signals, rather than relying on external labels provided by humans.	MIT Tech Review, Gartner 2024	Closer to market (7-9)
22	Gen AI	AI Avatar	An AI avatar is a digital representation of a person that uses artificial intelligence (AI) to simulate human-like features, behaviours, and interactions.	Gartner 2024	Emerging (4-6)
23	Gen AI	Digital Twins	A digital twin is a virtual representation of an object or system designed to accurately reflect a physical object.	Gartner 2024	Emerging (4-6)
24	Gen AI	Spatial Computing	Spatial computing is a technology that combines the physical world with virtual content to enable digital objects to interact with the physical environment	Gartner 2024	Closer to market (7-9)
25	Sensors & IoT	Augmented Workforce	Workforce enhanced by sensors & IoT devices & intelligence	Gartner 2024	Closer to market (7-9)
26	Sensors & IoT	Intelligent surfaces	Reconfigurable Intelligent Surfaces (RIS) are surfaces that can manipulate electromagnetic waves to improve wireless communication. They are also known as Intelligent Reflecting Surfaces or Software-Defined Surfaces	WEF 2024	Emerging (4-6)
27	Sensors & IoT	Paper sensors	Paper-based sensors detect food spoilage gases without added moisture. Integrated into packaging with NFC tags, they enable consumers to use smartphones for food freshness, potentially replacing traditional expiry dates, reducing waste	EU Eyes on Future	Emerging (4-6)
28	Connectivity	High Altitude platforms stations (HAPS)	High altitude platforms (HAPs) are aircraft or airships that are positioned in the stratosphere, which is between 17 and 22 kilometres above the ground.	WEF 2024	Novel (1-3)
29	Connectivity	Integrated sensing & Communications	Improved Wi-Fi-enabled object communication with an energy-efficient design called Wi-Fi-IoT, using an innovative PHY approach for extended IoT battery life, ideal for automated household supply reordering.	WEF 2024	Emerging (4-6)
30	Connectivity	LEO Satellites	Low Earth Orbit Satellites	Gartner 2024	Closer to market (7-9)

Sl. No.	Categorization	Technology	Description	Sources	Tech Readiness Level
31	Connectivity	Private 5G	Private 5G is a wireless network technology that provides fifth generation (5G) cellular connectivity for private network use cases	Gartner 2024	Closer to market (7-9)
32	Connectivity	Wireless power transfer	Emerging wireless power tech for SmallSats resolves connector issues in harsh environments. Despite inefficiencies, ongoing advancements promise more reliable space power systems, crucial for future space economy at larger scales.	EU Eyes on Future	Closer to market (7-9)
33	AR/VR & Metaverse	Immersive Tech/Smart spaces	Physical world mapped in an AR/VR environment as well as smart devices	WEF 2024	Closer to market (7-9)
34	AR/VR & Metaverse	Multimodal user interfaces	Multimodal interfaces process two or more combined user input modes, such as speech, pen, touch, manual gestures, and gaze, in a coordinated manner with multimedia system output.	Gartner 2024	Emerging (4-6)
35	AR/VR & Metaverse	Mixed Reality Headsets	Headsets which bring physical and virtual worlds together	MIT Tech Review 2024	Closer to market (7-9)
36	Energy Mgmt. & Optimization	Elastocalorics	Elastocaloric materials are solids that can undergo reversible phase transformations when stress is applied or removed. These transformations release or absorb latent heat, causing the material to heat up or cool down. This effect is called the elastocaloric effect	WEF 2024	Novel (1-3)
37	Energy Mgmt. & Optimization	Carbon Capture Tech	Technologies to capture carbon from various processes	WEF 2024	Emerging (4-6)
38	Energy Mgmt. & Optimization	Enhanced geothermal systems		MIT Tech Review 2024	Novel(1-3)
39	Energy Mgmt. & Optimization	Energy Kites	Energy kites are a proposed innovation that use wind power to generate electricity. They are designed to fly autonomously in loops, using eight rotors that spin as the wind moves through them to drive a generator.	EU Eyes on Future	Emerging (4-6)
40	Energy Mgmt. & Optimization	High Density Hydrogen Storage	High density hydrogen storage is a key technology for fuel cell and hydrogen advancement. Hydrogen has the highest energy per mass of any fuel, but its low ambient temperature density results in a low energy per unit volume. Storage of hydrogen in high density	EU Eyes on Future	Emerging (4-6)

Sl. No.	Categorization	Technology	Description	Sources	Tech Readiness Level
			environments		
41	Computational Models	Model Compression	Compressing ML models into low compute and storage environments in restricted domains	Gartner 2024	Close to market (7-9)
42	Computational Models	Neuromorphic computing	Computing mimicking human brain	Gartner 2024	Emerging (4-6)
43	Computational Models	Tokenisation	Tokenization is a process that replaces sensitive data with non-sensitive substitutes, called tokens. Tokens are unique identifiers that retain all the relevant information about the data without compromising its security	Gartner 2024	Close to market (7-9)
44	Computational Models	Blockchain	Blockchain technology is an advanced database mechanism that allows transparent information sharing within a business network	Gartner 2024, 2023	Close to market (7-9)
45	Computational Models	Knowledge Graphs	In knowledge representation and reasoning, a knowledge graph is a knowledge base that uses a graph-structured data model or topology to represent and operate on data	Gartner 2024	Close to market (7-9)
46	Hardware Architectures	Quantum processors	Quantum computing processors	Gartner 2024, EU Eyes on Future	Emerging (4-6)
47	Hardware Architectures	Hyperscale Edge Computing	Hyperscale edge computing is a type of distributed computing that involves placing large-scale computing resources, like storage and servers, near the edge of a network, closer to devices and end users	Gartner 2024, MIT Tech Review 2024	Close to market (7-9)
48	Hardware Architectures	AI Chip/chiplets	AI in special chips or small chiplets designed for some custom purpose	Gartner 2024, MIT Tech Review 2024	Emerging (4-6)
49	Hardware Architectures	Flexible electronics	Flexible electronics power wearable technologies, enabling new health monitoring devices and textile electronics. Advances in soft BMIs promise better brain-machine integration, aiding neurological research, but ethical and recycling concerns remain	EU Eyes on Future	Novel (1-3)
50	Hardware Architectures	LIDAR on chips	LIDAR technology on chips	EU Eyes on Future	Novel (1-3)

Sl. No.	Categorization	Technology	Description	Sources	Tech Readiness Level
51	Hardware Architectures	Nano magnetic computing	The device uses magnetic fields to carry out computation rather than shuttling electricity around, so it consumes far less power.	EU Eyes on future	Novel (1-3)
52	Material Science	Super-efficient solar cells	High energy generation from solar cells	EU Eyes on future	Novel (1-3)
53	Material Science	Anti-microbial packaging	Packaging that inhibits microbial growth	EU Eyes on Future	Novel (1-3)
54	Material Science	Low-cost batteries	Low-cost batteries for various needs	EU Eyes on Future	Emerging (4-6)
55	Material Science	Transparent wood	Researchers at the University of Maryland have advanced wood technology with a honeycomb structure, surpassing Plexiglass, and glass in durability. Innovations include bio-based polymers and enhanced heat resistance, ideal for eco-friendly building materials.	EU Eyes on Future	Novel (1-3)
56	Nuclear Tech	New fission/fusion tech	New fission /fusion tech	Stanford emerging tech	Novel (1-3)

Annexure 2: Sector evaluation summary

1. Financial Services

Financial Services	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	15%	15000+[1]	0.75	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	3	10%	12-15%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	5	10%	Allianz, Finastra, Equifax, EY, Envestnet, Oracle	0.5	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	2	10%	Federal Bank, SIB, Muthoot, Manappuram	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%	None		>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	2	15%	Kerala Bank	0.3	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	3	10%	Open, Jiffy	0.3	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	10%	DUK (Blockchain, AI)	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	2	10%	CSB, ESAF, Lulu Financials	0.2	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Total		**100%**		**2.65**	

[1] *GT Analysis 2024 based on market research - workforce size across startups, companies, institutes, and related entities in the respective sector are considered for assessment*

2. Space

Space	Score out of 5	Weightage (Emerging)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	5%	>10000[1]	0.25	>10000, 5 marks , 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	5	10%	16-20%	0.5	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	0	5%		0	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	5%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	2	10%	Indian Space Research Organisation (ISRO)	0.2	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	2	20%	Space Park	0.4	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	0	15%		0	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	5	15%	NIST, Indian Institute of Space Science and Technology (IIST), Indian Institutes of Science Education and Research (IISER), DUK,	0.75	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	2	15%	ISRO suppliers around TVM	0.3	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Total		**100%**		**2.4**	

3. Healthcare

Healthcare	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	3	15%	>10000[1]	0.45	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	3	10%	13-15%	0.3	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	2	10%	IQVIA	0.2	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	2	10%	Aster	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	2	10%	RCC, SCTIMST, Aster	0.2	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	5	15%	KMTC, Genome bank, Virology, TIMED	0.75	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	3	10%	OrthoFX, Carestack	0.3	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	5	10%	RG BioTech, RCC, SCTIMST	0.5	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	5	10%	Terumo, Agappe, Dentcare, HLL, Palakkad surgicals, Catalytic Research	0.5	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Total		**100%**		**3.4**	

4. Food & Agriculture

Food & Agriculture	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	3	15%	5k-10k[1]	0.45	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	5	10%	15-20%	0.5	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	2	10%	Orkla	0.2	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	2	15%	World Bank (WB) projects on FPO's	0.3	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	3	10%	Fresh to home	0.3	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	5	10%	RG Biotech, Kerala Agricultural University, NIST	0.5	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	5	10%	Multiple Marine and food processing units	0.5	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Total		**100%**		**2.75**	

5. Transportation & Logistics

Transportation and Logistics	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	15%	10000+ [1]	0.75	>10000, 5 marks , 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	2	10%	8-10%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	2	10%	Infosys manages FedEx from Kerala	0.2	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	2	10%	Adani port	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	2	10%	Cochin shipyard, port	0.2	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	2	15%	Vizhinjam, Kerala Maritime Board, Tourism Initiatives	0.3	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	2	10%	IBS Software	0.2	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	5	10%	Navalt, Multiple warehouse chains	0.5	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Total				**2.55**	

6. Property & Construction

Property and Construction	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	15%	5000-10000[1]	0.75	>10000, 5 marks , 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR	2	10%	5-7%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	5	15%	Eco friendly constructions, ASAP, ULCC Academy, INKEL Ltd	0.75	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	0	10%		0	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	10%	ULCC Academy	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	5	10%	Multiple real estate firms	0.5	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Total				**2.4**	

7. Digital Media and Entertainment

Digital Media and Entertainment	Score out of 5	Weightage (traditional)	Value	Weighted Score	Criteria
Talent Base in Kerala in numbers	5	15%	10000+[1]	0.75	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	3	10%	10-15%	0.3	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in that sector Kerala as GCC's / tech centres / acquired firms	2	10%	Nielsen	0.2	>5 - 5 marks, 1-5 - 2 marks
Number of NSE 1000 equivalent companies in that sector headquartered in Kerala	2	10%	Manorama	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of large PSUs in the area with tech divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Kerala Govt Initiatives aligning to the area	2	15%	Audio Visual Park, Toonz Academy	0.3	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable Startups or privately held firms in Kerala (with ~5 Mil USD funding)	0	10%		0	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant Sector related institutes (grad / pg)	2	10%	Toons Academy	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of MSME's in the area	5	10%	Toons, Epica, Mathrubhumi, movie houses etc.	0.5	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Media and Entertainment (Total)				**2.45**	

8. Education

Education	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	3	15%	5000-10000[1]	0.45	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	3	10%	10 - 13%	0.3	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	5	15%	NISH, Special needs education, KITES, ASAP	0.75	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	0	10%		0	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	2	10%	Large educational institutions	0.2	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Education (Total)				**1.7**	

9. Fashion & Jewellery

Fashion and Jewellery	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	15%	10000+[1]	0.75	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR	2	10%	7-10%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	2	10%	Kalyan,	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	0	15%		0	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	0	10%		0	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	10%	Institute of Gems and Jewellery, NIFT	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	5	10%	Many Jewelleries like Joy Alukkas, Malabar Gold	0.5	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Fashion and Jewellery (Total)				**1.85**	

10. Life Sciences

Life Sciences	Score out of 5	Weightage (Emerging)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	3	5%	5000+	0.15	>10000, 5 marks, 5k-10k => 3 marks, 1K-5K ==> 2 marks
Expected CAGR	2	10%	7-10%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	2	5%	Iqvia	0.1	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	5%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	2	20%	Genome datacentre, Life Science Park	0.4	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	3	15%	MedGenome	0.45	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	15%	RG Biotech, Institute of Virology	0.3	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	1	15%	Catalyst Research	0.15	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Life Sciences (Total)				**1.75**	

11. Sports

Sports	Score out of 5	Weightage (Emerging)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	3	5%	5000-10000[1]	0.15	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR in India	2	10%	8-10%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	0	5%		0	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	5%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	2	20%	Multiple sports programs	0.4	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	0	15%		0	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	15%	GV Raja School, PT Usha school	0.3	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	2	15%	Sporthood, Kerala blasters	0.3	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Sports (Total)				**1.35**	

12.Energy

Energy	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	15%	10000+ (BPCL, Adani gas, Kochi refineries)	0.75	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR	2	10%	9 - 11%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	2	10%	Baker Hughes, ReNew	0.2	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	2	10%	GAIL/BPCL Cochin refineries	0.2	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	5	15%	Gas pipeline, EV, Wind energy programs, Anert	0.75	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	3	10%		0.3	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	10%	Energy Management Centre	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	1	10%	Navalt	0.1	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Energy (Total)				**2.7**	

13. Assistive

Energy	Score out of 5	Weightage (Traditional)	Value	Weighted Score	Criteria
Talent base in Kerala by numbers	5	15%	10000+ (BPCL, Adani gas, Kochi refineries)	0.75	>10000, 5 marks, 5k-10k => 3 marks, 1K- 5K ==> 2 marks
Expected CAGR	2	10%	9 - 11%	0.2	>15% 5 marks, 10-15% - 3 marks, 5-10% - 2marks
Presence of Fortune 1000 companies in the sector, including those operating as GCCs, tech centres, or acquired firms in Kerala	2	10%	Baker Hughes, ReNew	0.2	>5 - 5 marks, 1-5 - 2 marks
Number of companies listed in the NSE 1000 headquartered in Kerala within the sector	0	10%		0	>5 - 5 marks, 1-5 - 2 marks
Presence of large public sector undertakings (PSUs) in the area with dedicated technology divisions	2	10%	GAIL/BPCL Cochin refineries	0.2	>5 - 5 marks, 1-5 - 2 marks
Initiatives by the Kerala government aligning with the sector	5	15%	Gas pipeline, EV, Wind energy programs, Anert	0.75	>3 initiatives 5 marks, 1 to 3 initiatives 2 marks
Notable startups or privately held firms in Kerala with approximately 5 million USD funding	3	10%		0.3	> 5 startups 5 marks, 1 to 5 startups - 3 marks
Relevant sector-related institutes offering graduate and postgraduate programs	2	10%	Energy Management Centre	0.2	>5 - 5 marks, 1-5 - 2 marks
Presence of MSMEs	1	10%	Navalt	0.1	>5 notable MSME's - 5 Marks, 3-5 2 marks,1-2 - 1 mark
Energy (Total)				**2.7**	

Annexure 3: Tech x sector interlock scoring

In each of the 13 sectors, the suitability of seven technology stacks is evaluated horizontally. This assessment considers the presence of relevant use cases and potential outcomes that Kerala could achieve by implementing technology within these sectors. If the assessment deems a suitable fit, the corresponding sector score is assigned to the Tech x Sector matrix interlock cell; otherwise, it is labelled as 'unmatched'. Subsequently, the total Tech x Sector interlock score is calculated. The top five sectors from the matrix are selected, focusing exclusively on their interconnections. No technologies are excluded due to their interconnected nature, falling under Trigger 2.

Verticals / Horizontals	Financial Services	Space	Healthcare & Life Sciences	Food & Agriculture	Transportation and Logistics	Digital Media and Entertainment	Property and Construction	Education	Fashion and Jewellery	Life Sciences	Sports	Energy	Assistive
Industry Cloud Platforms	2.7	2.4	3.4	2.8	2.6	2.5	2.4					2.7	
Genome Computing			3.4	2.8						1.8	1.4		
AR/VR and Metaverse		2.4	3.4			2.5	2.4	1.7	1.9	1.8	1.4		1.5
Sensor/IoT		2.4	3.4	2.8	2.6	2.5	2.4		1.9		1.4	2.7	1.5
Energy Management and Optimization		2.4	3.4									2.7	1.5
Communications Tech	2.7	2.4		2.8	2.6								
Gen AI	2.7	2.4	3.4	2.8		2.5		1.7	1.9	1.8	1.4	2.7	1.5
Total	**8.1**	**14.4**	**20.4**	**14**	**7.65**	**10**	**9.6**	**3.4**	**5.7**	**5.3**	**5.4**	**10.8**	**6**

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