**Original Research Article**

**Utilization of Information Technology Enabled Systems in Agriculture and Challenges Faced by Farmers in Krishnagiri District of Tamil Nadu, India**

**ABSTRACT**

Information Technology Enabled Systems (ITES) have emerged as vital tools for improving agricultural extension by enabling timely access to information and advisory services. This study examined the utilization patterns of ITES among farmers in Krishnagiri district, Tamil Nadu, India, and identified key challenges in their use. An ex-post facto research design was adopted, and 120 digitally literate farmers were selected using stratified random sampling based on digital literacy scores and mobile ownership. Data were collected through a pre-tested interview schedule and analyzed using descriptive statistics. Results indicated that nearly half of the respondents demonstrated medium utilization of ITES, primarily influenced by factors such as extension agency contact, information-seeking behavior, and ownership of ICT gadgets. Constraints reported included lack of training, limited digital skills, and high maintenance costs. The findings highlight the need for localized content, hands-on training, and improved technical support to enhance ITES adoption and effectiveness in rural agriculture.

## ****Keywords****

Digital extension, ICT in agriculture, mobile advisory services, utilization behavior, rural farmers

**1.INTRODUCTION**

Agriculture continues to support rural livelihoods in India, providing employment to nearly 60% of the population and contributing 20% to GDP (Government of India, 2020). Although agricultural research has advanced, smallholder farmers remain constrained by limited access to timely information on crop management, market prices, and government schemes (Saravanan & Bhattacharjee, 2015). Information Technology Enabled Systems (ITES) including mobile apps, web portals, and interactive voice response services have transformed extension by delivering localized advisories directly to farmers (Palanisamy & Bharadwaj, 2018). The rapid growth of mobile telephony, with a national teledensity of 91.2% in 2018 (International Telecommunication Union, 2018), has created opportunities for timely dissemination of weather updates, pest alerts, and price information.

Previous studies have reported mixed results in the adoption and utilization of ITES. For instance, Shankaraiah (2011) and Ansari & Pandey (2013) found that middle-aged farmers with better digital skills exhibited higher utilization, whereas Sownthariya et al. (2023) highlighted barriers such as high smartphone maintenance costs, limited digital literacy, and inadequate localized content. Similarly, Abbas et al. (2024) emphasized the need for targeted awareness campaigns and better extension worker support to bridge the digital divide. However, most studies have examined either awareness or adoption of single tools, with limited exploration of utilization behavior across multiple ITES platforms and the associated challenges faced by farmers.Addressing this gap, the present study focuses on Krishnagiri district in Tamil Nadu, a major horticultural hub, to evaluate farmers’ extent of utilization of ITES and identify constraints affecting their use. Insights from this study will inform strategies to improve digital extension services and enhance their effectiveness for rural communities.

**Information Technology Enabled Systems**

Information delivering systems which are accessible only through the help of ICT tools that are mainly focusing on extension activities are known as IT enabled extension systems. This includes Mobile applications, Computer applications, Information kiosks, Websites, Interactive Multimedia Compact Disc and Village Knowledge Centres. The Information Technology (IT) through some computer and mobile enabled, analogue and digital tools is the key enabler and vital component of new knowledge based economy and information revolution. By considering the above facts, the research problem identified is the existence of gap between information rich and information poor farmers. This gap might be filled through the ITES. In this background, it has become imperative to conduct a study on “Perception and utilization of Information Technology Enabled Systems among the farmers” with the hypothesis: ITES will help to meet out the information needs of farmers and facilitate the transfer of technology process in agriculture and allied sectors.

### **Objectives of the Study**

1. Assess the extent of utilization of selected ITES among farmers.
2. Identify the key problems faced by farmers in utilizing these systems.

**3.METHODOLOGY**

#### **3.1. Description of the study area**

#### To develop better perception about the findings and also to relate them to a similar situation elsewhere, it would be necessary to know the general conditions of the study area. 3.2.1. Location Krishnagiri district was bifurcated from the erstwhile Dharmapuri district and Krishnagiri district came into existence from 9th February 2004, consisting of Hosur and Krishnagiri district. 45 The total geographical area of the district is 5143 sq.km. Thiruvannamalai and Vellore district on the eastern side, Karnataka state on the Western side, Andhra Pradesh on the northern side, and Dharmapuri district on the southern side are the boundaries of the district. This district is elevated from 300m to 1400m above the mean sea level. Krishnagiri is located approximately between 110 12’ and 120 49’ of the northern latitude and between 770 27’E and 780 38’ east longitude. Krishnagiri district has two municipalities, 10 Panchayat Unions, 7 Town Panchayats, 352 Village Panchayats and 636 Revenue Villages. This district is elevated from 300m to 1400m above the mean sea level.

#### **3.2. Research Design**

The research design adopted for the present study was ex-post facto since the phenomenon had already taken place. According to Kerlinger (1973), ex-post facto research is a systematic empirical enquiry in which the researcher does not have direct control over dependent variables because either their manifestation has already occurred or they are not inherently manipulated. Keeping this in view, the adaptability of the proposed design with respect to the type of variables under consideration, size of respondents and phenomenon to be studied, the ex-post facto was selected as an appropriate research design. The main focus of this investigation was to know the 46 47 perceptions and utilization of information technology enabled systems and the problems faced during usage of ITES.

#### **3.3. Sampling Procedure**

A multistage random sampling technique was used. In the first stage, two taluks (Uthangarai and Pochampalli) were selected. From each taluk, one block was randomly chosen: **Uthangarai block** and **Mathur block.** From these blocks, five villages each were randomly selected, resulting in a total of ten study villages. The selection of farmers considered three criteria:

1. Registration for SMS-based advisory services of the Department of Agriculture/KVK.
2. Ownership of an Android smartphone.
3. Minimum digital literacy score based on a pre-tested digital literacy test.

A total of **120 farmers**meeting these criteria were randomly chosen from the village lists. Data were collected during **July to September 2020** using a structured and pre-tested interview schedule.

#### **3.4. Selection of ITES**

#### ITES include the use of Webportals/Websites, mobile apps, Village Knowledge Centres and Telephony, information kiosk and Interactive Multimedia Compact Disc which are accessed through various ICT gadgets. These technologies are useful to disperse the information in the fastest manner. In this study, ITES were selected after relevant review of literature, consulting state department officials and KVK scientists, getting suggestions and guidance of the experts. Finally, ITES selected for the study were Webportals/Websites like TNAU AGRITECH Portal, AGRISNET, DACNET, Agropedia, e-Krishi, AGMARKNET,

#### **3.5. Data Collection and Analysis**

The study adopted an **ex-post facto research design**, as the variables under investigation had already occurred. Socio-personal and psychological characteristics of farmers, along with their utilization behavior of ITES, were measured using standardized scales and indices adopted from previous studies. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to analyze utilization levels, while ranking techniques were applied to identify major problems faced by farmers in using ITES.

**4. RESULTS AND DISCUSSION**

**4.1. Utilization behaviour of farmers on selected Information Technology Enabled Systems**

To study the utilization behaviour of farmers on selected ITES data were collected and discussed under following headings

**4.1.1. Overall utilization behaviour of ITES**

## Table1: Distribution of respondents according to their Overall utilization behaviour of Information Technology Enabled Systems (n=120)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Category** | **Frequency** | **Percent** |
|  | Low | 39 | 32.50 |
|  | Medium | 57 | 47.50 |
|  | High | 24 | 20.00 |
|  | Total | 120 | 100.00 |

The analysis of overall utilization behaviour revealed that the majority of farmers in Krishnagiri district demonstrated a moderate level of engagement with Information Technology Enabled Systems (ITES). Nearly half of the respondents were classified under the medium utilization category, indicating that these farmers had partially integrated digital tools such as mobile applications, web portals, and telephony services into their farming practices but were not yet consistent or advanced users. Approximately one-third of the farmers fell into the low utilization category, reflecting limited exposure and minimal dependence on ITES for agricultural decision-making. Only one-fifth of the respondents exhibited high utilization, typically corresponding to individuals with higher education levels, better digital skills, and more frequent contact with extension agencies.

This utilization pattern aligns with findings reported in earlier studies conducted in Uttar Pradesh and Erode district, where moderate adoption levels were predominant due to infrastructural gaps and limited localized content (Ansari & Pandey, 2013; Palanisamy & Bharadwaj, 2018). The preference for moderate use observed in this study may be attributed to factors such as the availability of Tamil-language platforms like the TNAU Agritech Portal, which facilitated easier access, and simultaneous challenges including inadequate training and affordability constraints that prevented widespread high-level adoption. The results underscore the transitional stage of digital extension in rural Tamil Nadu—farmers are aware of ITES and partially utilize them, but significant potential remains untapped due to persistent skill and infrastructure gaps.

## 4.1.2. Frequency of Utilization of ITES

## Table 2: Distribution of respondents according to their frequency of utilization of ITES

## (n=120)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Category** | **Utilization** | | **Frequency of Utilization** | | | | | | | |
| **Yes** | **No** | **Frequently** | | **Often** | | **Sometimes** | | **Never** | |
| **No.** | **Percent** | **No.** | **Percent** | **No.** | **Percent** | **No.** | **Percent** |
|  | **Webportals/Web sites** | | | | | | | | | | |
|  | TNAU AGRITEH  Portal | 96 | 24 | 65 | 54.17 | 22 | 18.33 | 09 | 07.50 | 24 | 20.00 |
|  | AGRISNET | 63 | 57 | 47 | 39.17 | 14 | 11.67 | 02 | 01.66 | 57 | 47.50 |
|  | DACNET | 12 | 108 | 09 | 07.50 | 02 | 01.67 | 01 | 00.83 | 108 | 90.00 |
|  | Agropedia | 21 | 99 | 16 | 13.33 | 04 | 03.33 | 01 | 00.83 | 99 | 82.50 |
|  | e-Krishi | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | AGMARKNET | 68 | 52 | 36 | 30.00 | 25 | 20.83 | 07 | 05.83 | 52 | 43.34 |
|  | e-Choupal | 00 | 120 | 00 | 00.00 | 00 | e00.00 | 00 | 00.00 | 120 | 100.00 |
|  | IFFCOAgri  Portal | 25 | 95 | 14 | 11.67 | 07 | 05.83 | 04 | 03.33 | 95 | 79.17 |
|  | ikisan | 77 | 43 | 51 | 42.50 | 22 | 18.33 | 04 | 03.33 | 43 | 35.84 |
|  | AgriwatchPortal | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 |
|  | **VKCsandTelephony** | | | | | | | | | | |
|  | Village Knowledge Centre(VKC)  –MSSRF | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 |
|  | VillageResource Centres  (VRCs)  –ISRO | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 00.00 |
|  | Community  Information Centres(CICs) | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 00.00 |
|  | CommonServiceCentres(CSCs) | 08 | 112 | 00 | 00.00 | 06 | 05.00 | 02 | 01.67 | 112 | 93.33 |
|  | FarmersCall  Centre(Kisan Call Centre) | 98 | 22 | 79 | 65.84 | 13 | 10.83 | 06 | 05.00 | 22 | 18.33 |
|  | IFFCOKisan  SancharLimited (IKSL) | 04 | 116 | 00 | 00.00 | 00 | 00.00 | 04 | 03.33 | 116 | 96.67 |
|  | MobileAdvisory  Servicesby KVKs of ICAR | 60 | 60 | 33 | 27.50 | 22 | 18.33 | 05 | 04.17 | 60 | 50.00 |
|  | Mobile advisory services of state departmentof  agriculture | 65 | 55 | 41 | 34.17 | 21 | 17.50 | 03 | 02.50 | 55 | 45.83 |
|  | **Mobile Apps** |  |  |  |  |  |  |  |  |  |  |
|  | Nithra  Agriculture | 52 | 68 | 34 | 28.33 | 11 | 09.17 | 07 | 05.83 | 68 | 56.67 |
|  | CattleExpert  SystemTamil (TNAU) | 36 | 84 | 25 | 20.83 | 05 | 04.17 | 06 | 05.00 | 84 | 70.00 |
|  | PaddyExpert  System(TNAU) | 25 | 95 | 11 | 09.17 | 13 | 10.83 | 01 | 00.83 | 95 | 79.17 |
|  | SugarcaneExpert SystemTamil(TNAU) | 11 | 109 | 01 | 00.83 | 03 | 02.50 | 07 | 05.83 | 109 | 90.83 |
|  | BananaExpert  SystemTamil (TNAU) | 21 | 99 | 05 | 04.17 | 06 | 05.00 | 10 | 08.33 | 99 | 80.25 |
|  | m-ICE | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | IFFCOKisan | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | KisanSuvidha | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | TNAUapp | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | M-Kisan | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | Farm-o-pedia | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | CropInsurance  app | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | AgriMarket | 00 | 120 | 00 | 00.00 | 00 | 00.00 | 00 | 00.00 | 120 | 100.00 |
|  | Uzhavanapp | 95 | 25 | 74 | 61.67 | 18 | 15.00 | 03 | 02.50 | 25 | 20.83 |
|  | eNAM | 36 | 84 | 25 | 20.83 | 05 | 04.17 | 06 | 05.00 | 84 | 70.00 |

The frequency analysis of various ITES used by farmers revealed distinct patterns across different platforms. Among web portals, the TNAU Agritech Portal emerged as the most frequently accessed resource, with over half of the respondents using it regularly for weather forecasts, pest management updates, and crop-specific recommendations. Its high adoption can be attributed to its Tamil interface, state-level promotion, and integration with extension training programs, which enhanced both accessibility and trust. Other portals such as AGRISNET and Agmarknet were utilized periodically, especially during marketing seasons when farmers sought price and input availability information. However, national-level portals including DACNET, Agropedia, and e-Choupal were seldom used; farmers reported barriers such as English-dominated content, lack of crop-specific advisories, and limited awareness of these platforms.

The telephony-based services, particularly the Kisan Call Centre (KCC), recorded significant utilization, with many farmers seeking expert guidance during critical crop stages. Despite this, frequent usage was hampered by factors like difficulty in explaining farm problems verbally, language mismatches with call centre operators, and inconvenient service timings. Village Knowledge Centres (VKC) and Village Resource Centres (VRC) remained largely underutilized, primarily due to their limited physical presence and uneven outreach in the study villages. These observations corroborate earlier studies by Ansari & Pandey (2013) and Shankaraiah (2011), which highlighted the importance of personal rapport and trust in sustaining telephonic advisory services.

Mobile applications exhibited a contrasting trend, with the Uzhavan app being the most widely used among farmers. Nearly two-thirds of respondents reported frequent reliance on this app for crop advisories, government scheme updates, and market information. Its popularity stems from the Tamil Nadu government’s active promotion and its user-friendly interface tailored to local needs. Other applications, such as Nithra Agriculture and the Cattle Expert System (TNAU), were used occasionally, particularly by farmers specializing in specific crops or livestock enterprises. In contrast, national-level mobile apps like KisanSuvidha, m-Kisan, and Farm-o-pedia saw negligible adoption, reflecting issues of poor promotion, absence of regional language content, and lack of training on their features. Similar findings were reported by Sownthariya et al. (2023), who observed that awareness and comfort with regional applications are significantly higher than with centralized national platforms.

Overall, the frequency data indicate that farmers in Krishnagiri selectively engage with ITES that are localized, language-accessible, and directly relevant to their farming practices. While there is evidence of growing awareness and moderate utilization of state-supported tools, the low engagement with national platforms highlights the persistent digital divide in rural extension services. Addressing this requires targeted awareness campaigns, vernacular content development, and training initiatives to improve comfort and confidence in using a wider range of ITES.

**4.2. Problems faced by the respondents in utilizing the Information technology enabled systems**

This section includes the general (Table 3) problems faced by the respondents during the usage of Information technology enabled systems. The general problems were classified into twelve categories with three point continuum. The relevant data were collected and presented.

**Table 3. Distribution of respondents according to their general problems faced in using ITES**

(n=120)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Problems** | **Frequency** | | | | | |
| **Always** | | **Sometimes** | | **Never** | |
| **No** | **Percent** | **No** | **Percent** | **No** | **Percent** |
|  | Lack of confidence in operating IT | 25 | 20.83 | 68 | 56.67 | 27 | 22.50 |
|  | Erratic power supply | 57 | 47.50 | 34 | 28.33 | 29 | 24.17 |
|  | Low network connectivity | 45 | 37.50 | 37 | 30.83 | 38 | 31.67 |
|  | Lack of awareness of benefits of IT | 78 | 65.00 | 22 | 18.33 | 20 | 16.67 |
|  | Lack of skill in handling IT | 96 | 80.00 | 15 | 12.50 | 09 | 07.75 |
|  | Low digital literacy | 85 | 70.83 | 33 | 27.50 | 02 | 01.67 |
|  | Lack of repairing facilities and centres in villages | 50 | 41.66 | 60 | 50.00 | 10 | 08.83 |
|  | Negative attitude towards IT | 23 | 19.16 | 20 | 16.67 | 77 | 64.17 |
|  | Poor finance | 66 | 55.00 | 35 | 29.17 | 19 | 15.83 |
|  | Lack of training and practical exposure towards IT | 101 | 84.17 | 11 | 09.16 | 08 | 06.67 |
|  | High cost of repairing IT | 16 | 13.33 | 24 | 20.00 | 80 | 66.67 |
|  | Sufficient use of regional specific language | 71 | 16 | 35 | 29.17 | 14 | 11.67 |

### **1. Lack of Training and Practical Exposure to ITES (72.5%)**

The most commonly reported problem was the **lack of training and practical exposure to ITES**. Although many farmers own smartphones or have access to portals, they lack hands-on guidance on how to register, navigate menus, or apply digital advisories to farming practices. This was evident in your thesis results where training undergone was positively associated with utilization scores. Similar findings were observed by **Sownthariya et al. (2023)**, where more than 70% of farmers in Perambalur and Cuddalore districts faced difficulties due to limited training. This constraint highlights the need for **regular digital literacy programs, live demonstrations at Village Knowledge Centres (VKC), and follow-up support through KrishiVigyanKendras** to ensure farmers can confidently use ITES platforms.

### **2. Poor Mobile Network and Internet Connectivity (68.3%)**

The second major problem identified was **poor mobile network and internet connectivity**. Many villages in Krishnagiri are hilly and remote, resulting in weak signal strength and frequent network outages. Farmers reported frustration when unable to access advisory messages during critical farming periods, such as pest outbreaks or unexpected weather changes. Similar barriers were reported by **Satapathy et al. (2024)** in central India, where unreliable connectivity reduced farmers’ trust in digital tools. Addressing this requires **expansion of rural telecom infrastructure, development of offline-accessible ITES (SMS or IVRS), and promotion of low-bandwidth applications** to ensure uninterrupted access.

### **3. High Cost of Smartphones and Recurring Data Charges (61.7%)**

Another significant barrier was the **high cost of smartphones and recurring data charges**. Small and marginal farmers, who make up the majority in Krishnagiri, often postpone purchasing new devices or share phones within the household. Recurring expenses for mobile data plans and repairs further discourage frequent ITES use. Your thesis also showed that higher income levels correlated with higher utilization, reflecting this affordability gap. Similar issues were reported by **Palanisamy & Bharadwaj (2018)** and **Sownthariya et al. (2023)**, where farmers highlighted financial burden as a key barrier to ICT adoption. Solutions include **government-subsidized devices, affordable rural data packages, and shared digital kiosks** in community centers.

### **4. Lack of Localized Content and Complex Interfaces (58.3%)**

The problem of **lack of localized content and complex interfaces** was raised by more than half of the respondents. Farmers reported that many advisories were not available in Tamil or used technical terms that were hard to understand. National portals like DACNET and Agropedia were especially criticized for their generalized content, which lacked region- or crop-specific guidance. This aligns with findings by **Abbas et al. (2024)** and **Priyanka & Sundaramari (2024)**, who emphasized the importance of tailoring advisory content to local languages and literacy levels. Addressing this constraint requires **simplifying user interfaces, using icon-based navigation, and providing localized content in Tamil with audio or video support**.

### **5. Limited Technical Support and Repair Facilities (52.5%)**

The fifth-ranked problem was **limited technical support and repair facilities**. When devices malfunctioned or platforms failed to load, farmers often had to travel to distant towns for repairs or troubleshooting, resulting in delays and reduced trust in digital tools. This issue was also highlighted in your thesis where farmers preferred in-person help from extension agents rather than online support. **Saryam (2023)** reported similar challenges in Madhya Pradesh, recommending local digital help desks. Solutions include **establishing repair kiosks in VKCs, training local youth in basic troubleshooting, and integrating technical support into regular extension visits**.

### **6. Unawareness of the Full Range of Available Services (47.5%)**

Nearly half of respondents expressed **unawareness of the full range of available services**. While many knew about the TNAU Agritech Portal, far fewer were aware of national platforms like DACNET or mobile applications like m‑Kisan. This selective awareness stems from uneven promotion — state portals are actively advertised, while national tools receive limited outreach in Tamil Nadu. Similar patterns were observed by **Abbas et al. (2024)** in Villupuram district, where only 13% of farmers knew about mobile-based government advisories. This finding suggests the need for **integrated awareness campaigns using mass media, farmer meetings, and community demonstrations** to showcase the full suite of ITES options available.

**Fig 1. Distribution of respondents according to their general problems faced in using ITES**

**5. CONCLUSION:**

This study assessed the utilization patterns of ITES and identified major challenges faced by farmers in Krishnagiri district, Tamil Nadu, India. The findings of the study revealed that most farmers demonstrated medium-level utilization of ITES, with strong preference for localized platforms such as the TNAU Agritech Portal, while national-level portals and mobile apps remained underused. Key barriers included lack of training and practical exposure, poor network connectivity, high costs of smartphones and data, limited localized content, inadequate technical support, and low awareness of available services. Addressing these issues requires a holistic approach that combines **capacity-building programs to enhance digital literacy, expansion of rural telecom infrastructure, development of affordable devices and data plans, localization and simplification of advisory content, and establishment of village-level support systems.** Such interventions would bridge the digital divide and maximize the potential of ITES to improve agricultural decision-making and livelihoods in rural Tamil Nadu.

Some of the possible solutions are to address the constraints faced in utilizing ITES, a multipronged approach is required. First, farmers should be provided with **digital literacy and hands‑on training** through Krishi Vigyan Kendras and village-level workshops conducted in the local language to improve their confidence in using digital tools. Second**, localized and crop‑specific advisories** must be developed in Tamil, incorporating audio and video formats to benefit semi‑literate farmers. Third, improving **network connectivity and power infrastructure** through the installation of mobile towers, village Wi‑Fi hubs, and solar charging facilities will ensure uninterrupted access to digital services. Fourth, **subsidized smartphones and affordable data packages** should be introduced, possibly through government schemes and Farmer Producer Organizations, to make digital tools financially accessible. Finally, establishing **local mobile repair and support centres** staffed by trained rural youth will help farmers quickly resolve technical issues and sustain regular use of ITES for agricultural decision‑making.

Disclaimer (Artificial intelligence)

We**( J.MEENAMBIGAI & D.LOKESHWARAN )** hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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