INDIAN FERTILITY SOCIETY

A Revolutionary White Paper
By The Indian Fertility Society For Sustainability in ART Practice in India and The Road Ahead

Editors

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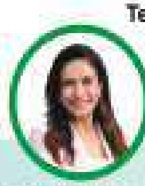
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Green ART: A Revolutionary White Paper by the Indian Fertility Society for Sustainability in ART Practice in India and the Road Ahead

INTRODUCTION AND BACKGROUND

The world is sitting atop a ticking time bomb. In the race for supremacy, the reckless action of the human race has done irrevocable damage to Mother Earth. Postindustrialization, especially in the last 1000 years, incessant use of fossil fuels for various human activities has drastically increased carbon dioxide in the atmosphere. As a matter of fact, all processes and human activity generate GHG (greenhouse gas) emissions under the scope 1,2,3 categories as the case may be and are leading to the planetary crisis of climate change, biodiversity loss, and land degradation. If no changes are brought about by the end of the century, the Earth would be 4°C warmer. The social, environmental, and economic consequences of all this can be devastating, and hence the global rise in temperature has to be curtailed to below 2°C, preferably below 1.5°. In 2015, at the United Nations COP27 Climate Change Conference, the UN adopted the Paris Treaty-2030 agenda for Sustainable Development and declared 17 goals, wherein the target was to bring prosperity to the world while tackling climate change. COP30 has just concluded on 21st November 2025 in Belem, Brazil, where the health front scored several incremental victories. The outcome text included the first direct acknowledgment of the health benefits of mitigating emissions in a COP decision, while the Belem Health Action Plan, a voluntary policy package of best practices for adapting health systems to the climate crisis, was declared.

India ranks as the world's 5th most polluted country. Sadly, our capital city, New Delhi, is consistently ranked the world's most polluted capital city, and several other

Indian cities are also impacted similarly. The environmental pollution significantly impacts human reproductive health, resulting in lower fertility rates and reduced success in in vitro fertilization (IVF) treatments. The primary culprits are fine particulate matter (PM 2.5) and other toxins (nitrogen oxides, sulfur oxides, heavy metals) from vehicles, industry, and biomass burning, which can penetrate into human bodies and cause systemic inflammation and oxidative stress.

The main effects on fertility and IVF outcomes include:

- Reduced sperm quality with regard to decreased sperm count, motility, morphology, and DNA damage.
- Compromised female fertility due to disrupted hormone levels, decline in ovarian reserve, higher risk of miscarriage.
- Lowered IVF success rates as high pollution levels result in lower egg retrieval, reduced embryo quality, reduced implantation rates and lowered live birth rates. High PM10 levels could drastically reduce the successful birth rate.

Paradoxically, the healthcare industry which is a beacon of healing and hope is also a significant contributor to the environmental pollution and the greenhouse gas emissions. The healthcare carbon footprint is 4.4% of global net emissions. ART procedures themselves have a significant adverse environmental impact due to their intense continuous energy consumption, waste generation, laboratory culture systems using disposable and single-use plastics at multiple levels, gases required for cryopreservation, the fossil fuel dependency for transport of gases and consumables, etc.

The ART sector has the potential for rapid expansion driven by increased demand and technological advancement, with a projected CAGR (compound annual growth rate) of 16.5%. Currently, about 2–2.5 lakh IVF cycles are done annually, with this figure expected to triple by the next 5 years. A single IVF cycle generates 1.19 tons of CO_2 emissions, and hence, the cumulative carbon footprint of IVF cycles cannot be trivialized. The widespread use of plastics in IVF is extremely concerning. Plastics, microplastics, and products of their breakdown are dangerous environmental pollutants that are found in landfills and water bodies. Microplastics permeate the body and are negatively impacting human fertility through endocrine-disrupting properties.[1]

This white Paper aims to understand how, at multiple operational levels, the ART practice can integrate sustainability without compromising outcomes. So, the proposed interventions for lowering carbon footprint were executed at the 5 IVF centers across India chosen for a pilot project. The findings and conclusions drawn up at the end of the pilot project are presented in this white Paper.

The larger message is to spread awareness to all major stakeholders of the ART sector, specifically in the context of the Indian subcontinent, the IVF doctors, embryologists, patient advocates, healthcare manufacturing industry, environmental organizations, policy makers, government agencies, and standardize guidelines for achieving the goal of sustainability. A special focus is also being placed on promoting "Make in India", which will positively impact both environmental and social sustainability efforts.

TEAM STRUCTURE AND IMPLEMENTATION OF THE PROGRAM

- The exercise started under the aegis of IFS with the idea being the brainchild and vision of the President of IFS, Dr Prof (Col) Pankaj Talwar, to do course correction on the ground to bring down carbon emissions of the IVF sector.
- A team was created by choosing members—clinicians and embryologists from across the country, and nine teams were formed. Each team had two senior experts as team leaders and 4–6 team members, with a total of 62 members in this pan-India team. The team is being led by President IFS-Dr Prof (Col) Pankaj Talwar, General Secretary IFS-Dr Prof Shweta Mittal. Dr Sonia Mallik blessed the project as its mentor, and coordination for the project was spearheaded by Dr Meenu Vashisht Ahuja.
- At the outset, a review of available relevant literature was carried out; there was very scant information and no data in the Indian context of sustainability interventions in the IVF sector.
- Structured discussions and online meetings were carried out with the key team members to brainstorm on how to ideate and execute the sustainability aspects practically in IVF practice. All steps were executed after collective consent, decision-making, and shared insights. About 10 such internal meetings were carried out online.
- National online CMEs/webinars for clinicians and embryologists were conducted, which were 6 in number, with around 400 views of uploaded YouTube recordings of the above webinars. In the conduct of these webinars, opinions and inputs of other experts, like ESG consultants, environmentalists, were taken.
- Social engagement on the topic was attempted by publishing monthly bulletins by each of our teams for the IVF fraternity. Bulletins, thus released, were 10 in number.
- The general public and the medical fraternity were engaged by outreach activities such as inaugurating the program at holy ghats of Varanasi with a

public address in May 2025, and a walkathon was carried out on World IVF Day on July 25, 2025 to reiterate our promise to the sustainability drive.

- Celebration of the World Environment Day on June 5, 2025 was carried out with an online webinar when we declared our chosen 4 pilot project centers from across the country after shortlisting from the numerous applicants.
- An interactive Panel discussion on sustainability in IVF on the occasion of World IVF Day was held at the 6th National IVF Summit held in New Delhi, where a very sincere attempt was made to put across the perspective of our mission successfully. This hour-long panel discussion, termed the “SUSTAINABILITY HOUR,” was carried out by IFS in collaboration with IHW.
- Our core team drew up criteria for the assessment of Green Clinics/centers chosen for the pilot project. The centers were evaluated for their sustainability criteria adherence by way of online video inspection by the assessor team on 2 occasions—first inspection on 19th and 20th Aug 2025 and follow-up inspection on November 2025. The centers were evaluated at baseline for adherence to the criteria, which were documented. The assessment team suggested the changes that should be incorporated within each center and in the given time period of 3 months. At the second inspection, the changes that were carried out were noted. All the chosen centers submitted their data to the assessment team.

ENVIRONMENTAL SUSTAINABILITY

Designing Energy-efficient, Sustainable IVF Clinics and Labs

Use passive cooling and building envelope strategies: One of the first lines of defence against high energy consumption is an optimized building envelope by using roof paints with a high reflective index, clay tile roofs with water drippers.[2] Orientation of the building such that it minimizes large surfaces or windows facing west, providing external shading by using overhangs, louvers, or trees, and ventilation. Incorporating concepts like thermal insulation of the roof and walls (for walls using AAC blocks). Implementing the passive design measures directly translates to energy savings.

High-performance Glazing and windows: Double or triple-glazed windows can reduce heat gain or loss by around 50–70%.[3] Ensure proper sealing around windows; by eliminating draughts, the HVAC system can operate more efficiently. Using tinted low-E glass can cut solar heat gain with only modestly reducing visible light.

Renewable Energy Integration

Solar photovoltaic systems (solar systems) are well-suited to India, which has abundant sunshine year-round.[4,5] A center can first carry out an energy audit and load assessment to understand its typical consumption patterns. Most urban IVF units can opt for a grid-tied solar PV system with net metering. These should be integrated with back-up power with battery inverters like hybrid inverters with battery storage or a UPS system based on Li-ion batteries charged by solar.

Automation and Smart Energy Management

For new IVF centers (BMS), Building Management Systems (BMS) is a centralized control system that monitors and manages a building's mechanical and electrical equipment, HVAC, lighting, ventilation, security, and fire alarm systems. Energy-efficient BMS strategies include demand-controlled ventilation, and smart scheduling of air handling units and pumps can trim energy use significantly.

For the existing IVF centers, IoT-based smart devices offer practical retrofit solutions like smart thermostats or AC controllers for split AC units, occupancy sensors for light and ventilation that are switched on only when someone is present.

Automation allows monitoring and analytics of energy usage, and data-driven adjustments ensure IVF clinics' energy use aligns with actual need.[6] This brings about cost reduction and a consistent indoor environment.

Energy-efficient HVAC Systems for IVF Labs

HVACs run continuously in the critical areas, are usually the single largest energy consumer in a clinic, and hence an energy-efficient HVAC system is paramount. The IVF lab area can have a dedicated HVAC zone separate from public areas. Using *(VFD) variable frequency drive* controls on fans and compressors allows the systems to ramp down when full capacity is not needed. IVF labs are typically maintained at a slightly higher positive pressure than adjacent areas to prevent ingress of contaminants. This is achieved by supplying more air than is exhausted. Modern HVAC units incorporate *EC (Electronically Commutated) motors* for fans and can adjust speed dynamically. By maintaining positive pressure only to the degree needed and using efficient fans, the system meets air quality needs at the lowest energy cost. Humidity control without overcooling by using *cooling coils with reheat using recovered heat* or dedicated dehumidifiers. For heat recovery ventilation, *Energy Recovery Ventilators (ERVs)* or heat exchangers can reclaim 60-70% of energy that would be lost.[7]

Sustainable Construction Material and Interior Finishes

- Eco-friendly wall and structural materials like *(AAC) Autoclaved Aerated Concrete blocks or (CSEB) Compressed Stabilized Earth Blocks* for construction.
- Recycled and local materials like terrazzo flooring with recycled chips or recycled aluminum for window frames.
- Low VOC paints and adhesives
- Sustainable furnishings and fixtures

Role of the Clinician in Making IVF Sustainable

The clinical side of IVF is carbon-footprint heavy. Sustainable IVF refers to a more environmentally friendly approach to IVF, focusing on reducing the use of resources and waste production without compromising the effectiveness of treatment.[7] Clinicians are in a unique position to bring in this change at multiple levels.

Reducing Energy Consumption

- Replace bulbs with LEDs, switch off equipment such as computers and monitors when not in use, reducing AC and heating use.
- Use Energy Star-certified equipment with smart features such as automatic shut-off or low power modes to help conserve electricity.
- Maintain equipment for optimal efficiency.
- Use a renewable energy source—solar energy.

Water Consumption

- Harvest rainwater (retrofitting rainwater harvesting systems into existing buildings is also possible, though it may require some modifications).
- Reuse treated wastewater, AC & RO filter discharge for cleaning, irrigation, etc.
- Install sensors or flow restrictors on faucets for controlled water flow at scrub stations.
- Fix leaky taps and dripping faucets promptly.

Save Paper

- Embrace digital records and prescriptions.
- Do not insist on printouts of lab reports, other investigations, etc.
- Avoid using paper plates and cups for patients and staff.
- Use greener alternatives like recycled Paper, bamboo paper, and washable microfiber cleaning cloths for cleaning.

Plastic and Polystyrene to be Avoided

- Replace plastic file folders with cardboard ones, plastic water bottles with glass bottles, and plastic plates and cutlery with wooden ones.
- Using recyclable coolers for transportation of medicines and media in cold chain conditions as an alternative to polystyrene coolers.

Miscellaneous

- Replace disposable gowns, caps, shoe covers, OT linen, etc., with reusable cloth ones.
- Reduce scope three emissions by encouraging Telemedicine, advising patients to avoid traveling to clinics or hospitals repeatedly, and administering gonadotropins by themselves.
- Scope 3 emissions are also reduced by streamlining procurement and inventory management, avoiding frequent reorders, and avoiding wastage, FIFO (first in first out)
- Proper waste segregation in clinics by having a central sorting station, removal of unnecessary bins, and waste disposal bags.

Biomedical Waste Management of ART Clinic

IVF lab typically operates around the clock with reliance on disposable plasticware, frequent usage of chemicals, and specialized culture media significantly increases the waste burden. Biowaste management in IVF labs is crucial for ensuring lab safety, regulatory compliance, and environmental sustainability. IVF labs generate a diverse range of biomedical waste, including general waste (like Paper and packaging), biological waste (such as blood, semen, and tissue), sharps (needles, blades), plastic disposables, chemical agents (cryoprotectants, sterilants), and electronic waste from outdated equipment. Each category requires specific handling, like biological and sharps waste need containment and incineration, plastics demand better recycling or biodegradable alternatives, and chemicals must be treated before disposal. Electronic waste from outdated equipment should be managed through authorized recyclers.

Proper waste segregation and management in healthcare facilities is essential not only for regulatory compliance but also for safeguarding public health and the environment. Proper waste segregation also ensures a good recycling process. Having a central sorting station helps to reduce the number of bins and waste disposal bags used. Also, the introduction of a small recycling bin at each workstation is a cost-effective strategy.[1] The historical sequence of 'take-make-use-dispose' has changed to 'take-make-use-refurbish-upgrade-recover-recycle', termed as CIRCULAR ECONOMY. This reduces the aggregate need for materials, cost, and consequently the GHG emissions.[8] In India, hospital waste is classified under distinct rules and color-coded systems to streamline safe handling, treatment, and disposal.

Biomedical Waste-color-coded Segregation (BMWM Rules 2016)

This rule mandates that hospitals segregate infectious and hazardous medical waste into specific-colored containers, each representing a waste type and its treatment pathway

- **Yellow bag-highly infectious waste**
  Treatment-incinerated or chemically treated and disposed of in secured landfills
- **Red bag-contaminated plastic waste**
  Autoclaving, followed by shredding and recycling.
- **White container-sharps and metals**
  Treatment: Autoclaving/dry heat sterilization, then encapsulation or destruction via shredders.
- **Blue container-glassware and metallic body implants**
  Treatment: Disinfection followed by recycling.[9]

General Waste—Solid Waste Management Rules, 2016

Waste from the hospital that does not pose a biological hazard is managed under the Solid Waste Management Rules, 2016. It includes:

- Wet waste, treatment-composting, bio-methanation, or organic waste converters
- Dry waste, treatment-segregated and sent for recycling or disposal through municipal channels.
- Construction and demolition waste treatment is sent to authorized C & D waste processing facilities.

Other Waste -Batteries, E-waste, Radioactive Waste (Atomic Energy Act 1962, Amendment 2015)

Healthcare facilities also generate other forms of specialized waste, governed by laws like the E-Waste Rules, Battery Waste Management Rules, and the Atomic Energy Act

- Batteries—lithium, lead acid batteries from UPS systems, monitors must be collected separately and returned to authorized recyclers
- E waste—obsolete computers, monitors, printers and electronic medical equipment. Same are segregated and sent to certified e-waste processing units.

  - There should be collaboration with suppliers that offer take back programs or use recyclable packaging.
  - Develop SOPs for waste segregation at the point of generation.
  - Appoint a green officer or sustainability champion to oversee and report on waste metrics.
  - Include waste KPIs in monthly audits.

Sustainable Embryology Laboratories

From an embryology perspective, the labs are intrinsically linked to overall carbon footprint of IVF due to several critical operational aspects like ubiquitous single-use plastics,[10] high energy consumption for maintaining controlled environments and cryopreservation logistics.

Some sustainable solutions to minimize the carbon footprint in our labs[11] are as follows:

- Minimise use of single-use plastics like culture dishes, pipettes, tubes, embryo transfer catheters, etc.[1]
- SOP adherence is critical to avoiding wastage of resources and ensuring standardization of procedures related to sustainability.[7]
  - Use the minimum number of tubes for follicular flushing, and reduce the number of dishes for each case so that oil usage will also be reduced.
  - Performing embryo culture in micro drops and not wells-droplet culture can enhance the paracrine effect.
  - Microdroplets are used in WOW-well on a well dish, which even decreases the culture media usage.[12]
  - Performing denudation in drops will maximize media utilization compared to denuding in big wells.
- Use "Made in India" disposables wherever possible. With manufacturing under ISO 13485 and GMP environments, Indian IVF disposables are proving to be sterile, biocompatible, traceable and clinically validated. Advantages of made in India disposables and local suppliers are-cost effectiveness, better supply reliability, customization, and drastically reduced scope 3 emissions.
- *Energy efficient equipment:* Using smart HVAC systems, energy star rated or high efficiency models of incubators, centrifuges, microscopes, refrigerators. Incorporate movement sensor lighting and IoT-based energy monitoring for real-time tracking and energy conservation. Energy efficiency is also ensured by improved insulation to reduce thermal loss.
- Shift to eco-certified, biodegradable cleaning agents to minimize environmental impact.

- *Use reusable lab-wear:* Caps, gowns, shoe covers-autoclavable, reusable cloth-based options.
- Digital patient records, lab logs, reports.
- Strict waste segregation inside our labs as well.
- Collaborate with vendors. Demand their ESG reports.
- Prioritize suppliers who use eco-friendly packaging, reduce hazardous chemicals in manufacturing, and conserve water and energy in production.

Cryogenics and Greenhouse Emissions

Cryobiology is an essential part of IVF and is necessary for cryopreservation of gametes, embryos at all stages, and ovarian tissue. The process of cryopreservation requires LN_2 and sometimes dry ice (CO_2) for preimplantation genetics laboratories and in research labs. However, this life-changing technology comes with an environmental cost. The transportation of LN_2 in specialized cylinders known as cryo-cans creates a significant environmental burden due to transportation using motor vehicles that operate on fossil fuels.[7,13] Nitrogen oxide is 300 times more potent as a greenhouse gas in comparison to CO_2.

LN_2 is produced through cryogenic distillation, which involves distilling, cooling, and condensing nitrogen gas from the air. Utilization of LN_2 also generates significant waste primarily through burn-off during transfer to and fro from storage tanks and storage itself. The carbon footprint of cryopreservation/cryo-storage is attributable to the LN_2 production process as well as its transportation to and its subsequent utilization.

Optimize cryo-storage space to reduce the number of tanks required, thereby lowering liquid nitrogen usage. Regularly check for and repair tank leaks.

Replacement of aluminum cryo-storage (5 years warranty) is exceeded by stainless steel (10 years warranty). Also, vaporization of LN_2 in stainless steel containers is less than in aluminium containers. Utilization of dry-shippers rather than LN_2 containers can help reduce the carbon footprint.

Establish "Standard Operating Procedures" (SOPs) for embryology-cryobiology utilizing minimal standard resources for effective and efficient cryopreservation resources in the Indian scenario.

Also, manufacturers of freezing media should individualize the packaging of freezing media, making separate pack sizes of vitrification cooling (freezing) and warming (thawing) media for oocytes and embryos.

SOCIAL SUSTAINABILITY

Since the first IVF birth in 1978, over 8 million babies have been born through ART. Despite its widespread success, IVF remains costly and environmentally burdensome. High costs make IVF inaccessible to millions, particularly in low- and middle-income countries. Green low-cost ART offers a chance to bridge this equity gap by making treatment accessible to underserved populations. Each IVF cycle can generate around 500 kg of CO_2. Green IVF focuses on reducing both costs and environmental impact by rethinking every step of the process.

- Ethical Practices
  - Leverage Telemedicine and virtual consults to reduce clinic visits and thereby reduce scope 3 emissions.
  - Minimize unnecessary scans and hormone injections
  - Is natural cycle/mild stimulation IVF being done where it is clinically relevant?
  - Minimize use of adjuvant drugs and give minimum luteal phase support
  - Single embryo transfer minimizes the risks of multiple pregnancies, reduces complications, and decreases medication use. It's also environmentally more sustainable, requiring fewer resources per successful pregnancy.
  - How many fresh transfers are being done where clinically relevant? Minimize non-essential freezing
- Staff education and formation of Green Teams
  - Take steps to sensitize and educate patients, staff, and co-workers on sustainable practices. Educate and empower the stakeholders.
  - Form a Green Team to implement, monitor, and rectify green practices. Recognize and reward as sustainable changes thrive on motivation. Celebrate the change-makers and let their stories inspire a cultural transformation.
- Green Audits
  - Establish KPIs/SPOs for self-audit to ensure quality work in a sustainable manner with regard to the lab work and biowaste management.
  - Clinics or organizations should release periodic sustainability reports in a standardized and quantifiable manner.
  - Spread awareness and reporting of 'Green Washing' at an individual level or organizational level.

ECONOMIC SUSTAINABILITY

Made in India Initiative

The 'Make in India' initiative was launched by the Prime Minister of India in 2014 with an aim to transform India into a global manufacturing hub.[14] The main objective is to reduce India's dependence on imports and promote domestic as well as foreign investment in the country.[6]

Currently, India has 70% dependence on imports for medical equipment, and the Medical Devices Policy 2023 has been devised to reduce this dependence.[15] This ambition is supported by various financial initiatives, most notably the Production-Linked Incentive (PLI) scheme, which provides financial aid to manufacturers of medical devices and In Vitro Diagnostic (IVD) devices.[15]

The above-mentioned policy promotes the establishment of dedicated medical device parks across the country for domestic manufacturing.[15] To support this initiative, the Assistance to Medical Device Clusters for Common Facilities (AMD-CF) scheme has been launched to provide financial incentives to the same.[15]

Regulations by the government under the Central Drugs Standard Control Organisation (CDSCO), the Bureau of Indian Standards (BIS), and Legal Metrology include a strategic ban on imports of refurbished, repaired, and second-hand medical devices. This helps to ensure patient safety and simultaneously helps to encourage domestic production.[16]

Domestic production of medical equipment also provides an opportunity to incorporate appropriate changes towards sustainable and green practices from the inception of design and manufacturing. This provides a scope for quality control in accordance with country's own standards rather than modifying what has been imported from outside.

A lot of emphasis has been given to R&D excellence under the PLI scheme[17] to develop energy-saving and environment-friendly high-impact laboratory equipment. One of the key concerns to be addressed is the single-use plastic and packaging material.[18] Research is underway to find appropriate sustainable solutions for the same.

After the introduction of the above-mentioned schemes by the Government of India, there has been a spectacular growth of the medical device industry, which was evaluated at 12 billion dollars in the year 2023–2024 and is projected to reach 50 billion dollars by 2025.[15] The Compound Annual Growth Rate (CAGR) is estimated at an impressive 15% over the past 3 years.[15]

Alongside the medical device industry, the Indian pharmaceutical sector has also shown tremendous growth and stands tall as the third largest producer of drugs and pharmaceuticals worldwide with a 20% share in the export of generic drugs. Statistically speaking, its market size is expected to reach 120 billion dollars by 2030.[20]

The above-mentioned industries have shown such impressive and fast growth due to the backing of the “Make in India”[19] initiative. Homegrown industries also provide an opportunity to develop environment-friendly sustainable IVF products.

Awareness and prerequisite for industries to obtain green certifications such as ISO 14001, etc., is reinforcing the drive towards environmentally friendly and sustainable production.

Steps of Execution of 'Make in India'

- Introducing government policies that are manufacturer-friendly and encouraging
- Creating Infrastructure (Manufacturing units, plants, etc.)
- Raw material procurement wherever required
- Promoting domestic manufacturing
- Strict quality control
- Maintaining storage standards
- Reducing transportation
- Establish R&D cell and Funding
- Trust building in IVF specialists and embryologists across India for using the indigenous product.
- Quality assurance and honest feedback systems for improvement
- During manufacturing, storage, and transportation, low GHG emission needs to be kept in mind.

Current Status and Challenges

- Most companies are either vendors or distributors (very few manufacturers), and they are importing most of the media and equipment from outside, thus increasing the cost with customs duties, taxes, etc.
- Most of the media is imported, although some domestic manufacturing has started (Long back, some IVF centers did in-house preparation of culture media, which is a learning lesson for us)
- Most incubators are imported (a few local companies are manufacturing and trials are budding, but need more assurance on QC, far from scaling up and actual clinical use)
- Hormonal drugs are mostly packaged in India (raw material procured from Germany or Korea, etc). Indian drugs are available and their use should be encouraged by reducing the cost for a similar quality.

- Consumables of IVF Grade are mostly imported. Some were tried in India, but QC issues were there in the past.
- Ovum pickup needles, ET catheters, etc., are mostly imported

SOLUTIONS

Policy and Regulatory Recommendations

- *Incentivize domestic production:* Incentives in the form of tax benefits and subsidies for manufacturing eco-friendly medical devices and consumables that are energy efficient and reusable should be given. Low-interest loans should be offered to encourage investment in research and development of indigenous IVF technologies.
- *Establish standards for equipment and consumables:* These should only be procured from sources that meet the requirements of eco-friendly standards. There should be a strict check using eco-labelling. Indigenous production and procurement should be encouraged.
- *Price control*: There should be regulations on the pricing of drugs and consumables to make them more affordable for patients.
- *Insurance coverage*: More insurance companies should be encouraged to include IVF treatment to reduce the financial burden on patients.
- *Concept of circular economy:* Industries and production houses that work on the principle of circular economy, like reuse, reprocess, and recycle, should be incentivized.[21]

Recommendations for the Manufacturing Industry

- Promoting Research and development in different ways:
  - *Providing research funds:* dedicated funds for research and development of innovative IVF technologies.
  - *Skill development* and training of the workforce including international exposure
  - *Encouraging collaborations* between research institutes, government hospitals, and private companies
- *Adopt renewable energy:* Renewable sources of energy like solar and wind energy should be encouraged for ART laboratories, clinics, and medical equipment manufacturing industries to reduce their carbon footprint.
- *Collaboration between academic research and manufacturing industries:* Collaboration between pharmaceutical companies, medical device

manufacturing industries, and academic research institutions should be encouraged to promote the development and adoption of green technologies and sustainable practices.

Research and Development Recommendations

- Conduct detailed LCAs (Life Cycle Assessments) focused on IVF treatments in the Indian setting. These assessments should cover every stage—from making the materials used to disposing of waste—to measure the environmental impact accurately. This information will help identify key problem areas and suggest where improvements are most needed.
- More research is necessary to understand how long-term, low-level exposure to environmental pollutants—both from the surroundings and inside clinics—affects the quality of eggs and sperm, embryo development, and pregnancy success in IVF. This will strengthen the case for the clinical benefits of adopting "Green IVF" practices.

The above analysis demonstrates that India's national policies, centered around the "Make in India" theme, are actually an idea that fosters self-reliance or *Atma Nirbharta*. But along with this initiative also comes a responsibility to have clean technologies that increasingly incorporate environmental sustainability.

On a broader perspective, this allows us not only to decrease the cost of the end product but also to have more stringent local control over environmental standards. When coupled with a more bio-based input and a biodegradable output, it would be a win-win situation for all. This would also lead to less reliance on imports, thus reducing the carbon footprint further.

In day-to-day clinical practice, it would also translate into lesser exposure of the patients to harmful substances and provide a more natural environment for embryo development, thereby increasing the chances of conception and a subsequent successful pregnancy.

RESULTS: THE MONITORING AND MEASUREMENT

Green ART Center Certification is a pilot project initiated as part of the Indian Fertility Society's (IFS) 'Green ART initiative' to improve sustainability in ART practices. From among the few centers that volunteered to be a part of this novel enterprise, 5 Centers (A,B,C,D,E) were shortlisted to be evaluated over a short 'trial' duration of 3 months. The process involved a pre-assessment virtual tour of all IVF centers and obtaining compliance data as per the set evaluation criteria encompassing 7 different aspects of the IVF unit. All centers were then given directives to follow certain practical green norms that would be feasible within the 3 month study period. The post-assessment evaluation also involved a virtual tour through all 5 centers as well as procurement of their datasheets.

It is noteworthy that all centers participating in this study were extremely enthusiastic in their approach and had certain efforts in common. Each center increased the use of natural/daylight and made conscious, judicious use of electricity and water. They all zealously formed their respective 'Green Teams' to create awareness about simple sustainable practices among staff, colleagues and patients. Sincere efforts are in place not only to lay emphasis on buying 'Made in India' products but also to purchase from vendors who comply by green norms and provide ESG certification.

This sincere endeavour aimed at initiating a thought process of consciously adapting 'green' measures to make the IVF setup more environment friendly. No drastic changes were anticipated and there was absolutely no intention of comparison between the 5 centers. Each center had its own unique attribute to contribute towards implementation of sustainable practices in the IVF clinics:

- Center A has got pedal sensors attached to OT Wash area taps to prevent excess loss of water.
- Center B has absolutely stopped the use of disposable caps and shifted to 100% use of recyclable/lint free fabric caps.
- Center C, almost a digitalized 'paperless' clinic, practices a minimal paper and plastic usage policy. This center also orders >60% of made in India products and promotes local vendors.
- Center D has Solar Panels generating 3MW energy installed at their IVF unit. This center is also unique in having plastic free premises and has established a waste recycling plant by the brand name 'Purana'. The hospital not only conserves water by judicious use and via installation of sensor pedals; but also has >100 rainwater harvesting sites in the institute to maintain ground water levels.
- Center E is also in the process of installing solar panels and tapping natural light by fixing large windows wherever possible at their center.

Since this was a Pilot study involving a short duration where initial period was consumed in trying to understand the implementation process, it was difficult to quantify every parameter and calculate the carbon footprint. For example, it was practically impossible to procure electric bills and measure the units of electricity consumed by every electric gadget used in the IVF centers. Similarly, the quantification of water consumption pre- and post-assessment was not feasible.

However, to objectify the data, quantitative evaluation of 10 basic study parameters was done by calculating the CO_2 emission and average CO_2 equivalent (CO_{2e}) by Life Cycle Assessment Methodology. Considering that this was a preliminary study, our target was to achieve a minimum of 20% decrease in CO_{2e} by each center. While 4 centers met this criteria, one center (Center D) did not show a significant decrease in carbon footprint. However, it may be noted that this IVF center is part of a huge multi-speciality hospital and incorporating any changes needed management level approvals; a task which was limited by the short duration of this study. Nevertheless, Center D already had strict green norms in place and also had advanced unique methodologies for tree plantation, water management, rain water harvesting etc, as already mentioned earlier. It was heartening and very promising to find positive changes incorporated by each of the 5 centers included in this study **(Tables 1-5)** as was evident by an overall significant decrease in percentage of CO_{2e} by these centers **(Table 6)** within the 3 month study period. Thus all 5 centers qualify for Green ART Certification.

This pilot project may yet be a very tiny, baby step towards what we all eventually aim to achieve. However, this small beginning is extremely essential before we take a giant leap forward. This study showed a significant difference in CO_{2e} made by a small group of 5 centers within a short span of <3 months by introducing very basic practical changes. Therefore, it is encouraging to imagine how a positive switch can be brought about if major changes are incorporated in scientific approach in a tightly regulated manner, both subjectively and objectively.

A futuristic, long-term and large scale multicentric project can have well defined key performance indicators (KPIs) for IVF centers (**Table 6**) before they can get green certification. This table offers a compilation of KPIs from various sources[1-4] and the numeric thresholds/benchmarks are **proposed targets** derived from best practice and internal goals, which are not yet standardized or validated by broad empirical data. The field is still in nascent stages and more research is warranted to arrive at universally acceptable performance indicators.

So, all in all, concerted efforts are in place and the wheel of eco-friendly viable methods is on the roll to reach its ultimate goal of net zero carbon footprints.

Tables 1 to 5 Average CO2 Equivalent (CO2e) calculated (per month or per 10 IVF Cycles, as applicable) by Life Cycle Assessment Methodology.

Table 1: Center A

IVF parameter	CO_{2e} Per unit	Pre-assessment	Post-assessment (after 3 months)	% Decrease in CO_{2e}
Paper	5g	100kg	50 kg	50%
Single use plastic bag	1.58 kg	79 kg	63.2 kg	20%
Disposable cups	10g	6 kg	4 kg	33%
1 kg single use plastic waste	3 kg	37.5kg	32kg	15%
40 W incandescent lamp/tubelight 8 h/day (per lamp/month)	7.8 kg	39kg	27kg	31%
14 W LED lights	1.25 kg/month	75 kg	38 kg	49.33%
Lab disposables/cycle	1.9 kg	100.7 kg	89.3 kg	11.3%
Disposable caps/use	0.1 kg	30 kg	0	100%
Disposable mask/use	0.02 kg	3 kg	0.4 kg	87%
Centrifuge run of 5 minutes	6.4 g	0.192 kg	0.15 kg	22%
Overall CO_{2e}		470.39 kg	304.05 kg	35.36%

Table 2: Center B

IVF parameter	CO_{2e} Per unit	Pre-assessment	Post-assessment (after 3 months)	% decrease in CO_{2e}
Paper	5 g	5 kg	4 kg	20%
Single use plastic bag	1.58 kg	90 kg	45 kg	50%
Disposable cups	10 g	2 kg	1 kg	50%
1 kg single use plastic waste	3 kg	3 kg	1.5 kg	50%
40 W incandescent lamp/tubelight 8 h/day (per lamp/month)	7.8 kg	93.6 kg	75 kg	20%
14 W LED lights	1.25 kg/month	60 kg	37.5 kg	37.5%
Lab disposables/cycle	1.9 kg	190 kg	160 kg	16%
Disposable caps/use	0.1 kg	30 kg	0	100%
Disposable mask/use	0.02 kg	3 kg	0.3 kg	90%
Centrifuge run of 5 minutes	6.4 g	0.384 kg	0.288 kg	25%
Overall CO_{2e}		477 kg	324.6 kg	32%

Table 3: Center C

IVF parameter	*CO_{2e} Per unit*	*Pre-assessment*	*Post-assessment (after 3 months)*	*% decrease in CO_{2e}*
Paper	5 g	3.5 kg	1 kg	71.5%
Single use plastic bag	1.58 kg	442.4 kg	189.6 kg	57%
Disposable cups	10 g	3 kg	1.5 kg	50%
1 kg single use plastic waste	3 kg	23.4 kg	18 kg	23%
40 W incandescent lamp/tubelight 8 h/day (per lamp/month)	7.8 kg	31.2 kg	24.4 kg	22%
14 W LED lights	1.25 kg/month	73 kg	33.6 kg	53.3%
Lab disposables/cycle	1.9 kg	58.5 kg	49 kg	16.2%
Disposable caps/use	0.1 kg	10 kg	3 kg	70%
Disposable mask/use	0.02 kg	2.2 kg	0.8 kg	63.6%
Centrifuge run of 5 minutes	6.4 g	0.66 kg	0.51 kg	22.7%
Overall CO_{2e}		648 kg	321 kg	51%

Table 4: Center D

IVF parameter	*CO_{2e} Per unit*	*Pre-assessment*	*Post-assessment (after 3 months)*	*% decrease in CO_{2e}*
Paper	5g	1.25 kg	1.25 kg	0%
Single use plastic bag	1.58 kg	105 kg	100 kg	5%
Disposable cups	30 g	1.5 kg	1.5 kg	0%
1 kg single use plastic waste	3 kg	9 kg	8 kg	11%
40 W incandescent lamp/tubelight 8 h/day (per lamp/month)	7.8 kg	60 kg	47 kg	22%
14 W LED lights	1.25 kg/month	25 kg	25 kg	0%
Lab disposables/cycle	1.9 kg	9.5 kg	9.5 kg	0%
Disposable caps/use	0.1 kg	10 kg	10 kg	0%
Disposable mask/use	0.02 kg	2 kg	2 kg	0%
Centrifuge run of 5 minutes	6.4 g	0.1536 kg	0.1536 kg	0%
Overall CO_{2e}		223 kg	204 kg	8.5% **

** Although the overall reduction in CO_{2e} is low, this center qualifies due to its unique green policies, as mentioned in the results section above

Table 5: Center E

IVF parameter	*CO_{2e} per unit*	*Pre-assessment*	*Post-assessment (after 3 months)*	*% decrease in CO_{2e}*
Paper	5 g	0.250 kg	0.175 kg	30%
Single use plastic bag	1.58 kg	15.8 kg	12 kg	24%
Disposable cups	10 g	0.3 kg	0.2 kg	33%
1 kg single use plastic waste	3 kg	15 kg	9 kg	40%
40 W incandescent lamp/tubelight 8 h/day (per lamp/month)	7.8	31.2 kg	23.4 kg	25%
50 W LED lights	4.8 kg/month	14.4 kg	14.4 kg	0%
Lab disposables/cycle	1.9 kg	19 kg	15.2 kg	20%
Disposable caps/use	0.1 kg	30 kg	22 kg	27%
Disposable mask/use	0.02 kg	1 kg	0.8 kg	20%
Centrifuge run for 5 minutes	6.4 g	1.2 kg	0.9 kg	25%
Overall CO_{2e}		128.15 kg	98.07 kg	23.47%

Table 6: Comparison of carbon footprint emission between the 5 centers pre- and post-assessment

	Pre-assessment CO_{2e}	*Post-assessment CO_{2e}*	*% decrease in CO_{2e}*	*P value (t test)*
Center A	470.39 kg	304.05 kg	35.36%	0.04(Significant)
Center B	477 kg	324.6 kg	32%	
Center C	648 kg	321kg	51%	
Center D	223kg	204 kg	8.5%	
Center E	128.15 kg	98.07 kg	23.47%	
Mean	(389.31) kg	(250.34) kg	(35.69%)	

KPIS FOR A GREEN ART CENTER

Category	*KPI*	*Definition/what it measures*	*Threshold (minimum acceptable)*	*Benchmark (best practice)*
1. Energy and carbon	Energy consumption per IVF cycle	Total kWh used per cycle	≤30–35 kWh/cycle	≤20–25 kWh/cycle
	HVAC Energy Efficiency Index	COP rating of cleanroom HVAC	COP ≥3.0	COP ≥4.0+
	Carbon footprint per IVF cycle	Total kg CO_2e per cycle	≤12–15 kg	≤8–10 kg
	Renewable energy %	Proportion of electricity from renewable sources	≥20–30%	≥50–70%
	Liquid nitrogen consumption	LN_2 used per stored sample/month	≤1.2–1.5 L/sample	≤0.7–1.0 L/sample
2. Waste reduction and circularity	Biomedical waste per cycle	Total kg of waste generated	≤1.2–1.5 kg	≤0.8–1.0 kg
	Plastics reduction index	Reduction in plastic consumables YoY	10–15% YoY	≥25–30% YoY
	Recyclable/biodegradable consumables	% of green consumables	≥40–50%	≥70–90%
	Waste segregation accuracy	Correct segregation rate	≥90%	100%
	Net waste reduction index	Composite metric for solid waste decrease	≥10% annual	≥20% annual
3. Water sustainability	Water consumption per cycle	Litres used per IVF cycle	≤80–100 L	≤50–70 L
	RO wastewater reuse	% of RO reject water reused	≥20–30%	≥50–60%
	Non-potable water for cleaning	Share of non-drinking water used	≥40–50%	≥70–80%
4. Green lab performance	VOC and particulate levels	Indoor air quality performance	VOC <25–30 µg/m^3	VOC <10–15 µg/m^3

Contd...

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Category	*KPI*	*Definition/ what it measures*	*Threshold (minimum acceptable)*	*Benchmark (best practice)*
	Incubator energy efficiency	kWh/hour per incubator	≤0.07–0.08 kWh/h	≤0.05–0.06 kWh/h
	Eco-friendly media packaging	% of media/products with reduced packaging	≥25–30%	≥60–70%
	Green cleaning chemicals	VOC-free, non-toxic cleaners	≥80%	100%
	Paperless workflow adoption	Digital records vs. paper usage	≥60% paper reduction	≥90–100%
5. Green procurement	Green-certified suppliers	Environmentally accredited vendors	≥40% suppliers	≥70–80%
	Packaging waste reduction	Supplier-level packaging reduction	≥20%	≥40–50%
	Local procurement ratio	Locally sourced consumables	≥40%	≥70%
6. Facility sustainability	Green building/LEED rating	Environmental design standards	LEED Bronze or basic	LEED Gold+ or Net Zero
	Indoor Environmental Quality (IEQ)	Lighting, noise, VOC, temperature	≥70% compliance	≥90–95%
	Carbon-neutral operations	Offset %	≥20%	≥50–100%
7. Staff and culture	Staff trained in Green ART SOPs	Green training completion	≥80%	100%
	Compliance with green SOPs	Lights-off, shutdown policy, reuse	≥85%	≥95–100%
	Staff behavioural energy savings	% reduction due to habits	≥10%	≥20–25%
8. Composite score	Green IVF Index (0–100)	Weighted sustainability score	≥60/100	≥80/100

Abbreviations: HVAC = Heating, Ventilation and Air Conditioning; COP = coefficient of proficiency; YOY = year over year; VOC = Volatile organic carbons; ESG = Environmental, Social and Governance; LEED = rating is a point based system for evaluating the sustainability and energy efficiency of buildings

FUTURE VISION—NOVEL IDEAS: MISSION NET ZERO BY 2045

It is imperative to take baby steps before we can attempt a giant leap and chart our way towards a green landscape in a phase-wise manner. Broadly, the changes can be incorporated in three phases:

1. Awareness, Understanding, and Dissemination of the Concept of Green ART.
2. Introduction of modifications that can be brought about within the existing setup by making conscious efforts in our daily practice.
3. To envision how we can make concerted efforts to design and construct sustainable structures that can serve as eco-friendly Green ART setups of the future.

As a team, our efforts are focused on introducing novel ideas and looking forward to a Net Zero state by 2045. So, we have to envisage a dream Green ART lab of the future, a sustainable model, at least 20 years ahead of time. To plan such a futuristic design, a lot of spadework on literature survey and research on viable options has been undertaken. We have structured a broad idea, and then the groundwork of laying a foundation with the introduction of basic designs has been initiated. The step-wise 15-point program spanning the next few years, as we envision it to be:

1. To identify key trouble areas where green changes need to be introduced
2. To carry out a further literature survey and research on sustainable options
3. To prepare a feasibility report after consulting experts in the field of Sustainable Development (Mechanical and Civil engineers, Architects, Interior designers)
4. To prepare a logistics report of implementable changes, also taking into consideration the geographical, technological, and economic factors.
5. To create awareness and identify IVF specialists who plan to start a new IVF center and are ready to abide by the green changes.
6. To appoint Green ART executives and train them regarding environmental audits
7. To implement, upon thorough investigation, the changes in construction design as a pilot trial
8. To Evaluate pre- and post-status in terms of carbon footprints
9. To Audit these 'new' green centers and provide Green IVF certification.
10. To monitor and carry annual audits for at least 5 years before the changes can be incorporated on a larger scale.
11. To bring about the necessary refinements and adjustments as deemed fit, after 5 years of pilot testing, and to evaluate the effectiveness of the experimental designs.

12. To carry out a full-scale confirmatory study with implementation of all design changes along with value-addition and upgradation with existing AI tools, in IVF centers across India.
13. To audit all the now-established Green ART Centers across India and concomitantly encourage patients to go to Green ART setups by creating public awareness programs.
14. The first-generation Green ART centers to guide and train the next generation.
15. To have a beautiful Green ART Landscape across India with negligible carbon footprint (if not the idealistic absolute Net Zero) by the end of 2045.

CONCLUSION

Climate change is now viewed as one of the most serious threats to the continued health and well-being of millions of people worldwide. Green ART project is an ambitious initiative to counter this grave monster from further spreading its fangs of destruction. While theoretically all this may look very appealing, fanciful, and doable, it is actually a very overwhelming task. At the same time, we have to be cautious that in pursuit of our goal towards sustainable IVF practices, we should not get too carried away and must consciously avoid Greenwashing. All the ideas under the green initiatives may appear fanciful, but are not as easy to practically implement. It is a continuous 'work in progress' so there are bound to be disappointments when things do not turn out as anticipated. We should take those failures in our stride and strive to find better alternatives rather than making tall claims about achievements that are not! Also, making minor changes in our daily practices does not qualify any clinic to be called a 'Green Clinic'. Major long term and diverse changes implemented effectively and credibly audited will make for a really transparent sustainable system. By future-proofing the IVF industry with eco-conscious innovations, reproductive medicine can continue to deliver life while safeguarding the planet for future generations. Every child born through IVF represents a hope for the future. Let us ensure that the world they inherit is one where life is cherished, not only in the confines of a laboratory but in the vast, interconnected ecosystem of our planet. Green ART is not a utopian dream—it is a pressing necessity and an opportunity to align miracles with sustainability. Let's Paint a Green Landscape. Happy Greening!

REFERENCES

1. Farlie F, Palmer GA, Cohen J, et al. Sustainability in the IVF laboratory: recommendations of an expert panel. Reprod Biomed Online. 2024;48(1):103600.

2. Rawat M, Singh RN. A comparative review of cool roof thermal performance in various regions. Energy Built Environ. 2022;3(3):327-47.
3. Alliance for an Energy Efficient Economy (AEEE). Projecting national energy saving from adoption of high-performance glazing by 2030. New Delhi: AEEE; 2018.
4. Singh J. Calculating ROI of rooftop solar for commercial buildings. Sun Photonics Pvt. Ltd. Blog; 2025.
5. Mathew M. Commercial and industrial businesses can earn 20-25% ROI by switching to solar. Mercom India; 2025.
6. Fernandez N, Xie Y, Katipamula S, et al. Impacts of commercial building controls on energy savings and peak load reduction. Pacific Northwest National Laboratory (PNNL-25985), U.S. DOE; 2017.
7. TekWorx. Green healthcare: how sustainable practices lower hospital energy costs. TekWorx Blog; 2023.
8. Thiel CL, Vigil-Garcia M, Nande S, et al. Environmental life cycle assessment of a U.S. hospital-based radiology practice. Radiology. 2024;313(2):e240398.
9. Biomedical waste management and handling rules, India. Available from: https://cpcb.nic.in/uploads/projects/bio-medical-waste/guidelines_healthcare_june_2018.pdf
10. Khoudja RY, Xu Y, Li T, et al. Better IVF outcomes following improvements in laboratory air quality. J Assist Reprod Genet. 2013;30(1):69-76.
11. FemTech World. Sustainability in the IVF laboratory: recommendations of an expert panel. Available from: https://www.femtechworld.co.uk/news/sustainability-in-the-ivf-laboratory-recommendations-of-an-expert-panel-ivf20/
12. Vajta G, Korösi T, Du Y, et al. The well-of-the-well system: an efficient approach to improve embryo development. Reprod Biomed Online. 2008;17(1):73-81.
13. Segal TR, Giudice LC. Systematic review of climate change effects on reproductive health. Fertil Steril. 2022;118(2):215-23.
14. Make in India for sustainable economic development in India. RJPN. Available from: https://rjpn.org/ijcspub/papers/IJCSP22D1042.pdf
15. Why India is poised to become a global hub for MedTech manufacturing. Invest India. Available from: https://www.investindia.gov.in/team-india-blogs/why-india-poised-become-global-hub-medtech-manufacturing
16. Setting the record straight: USTR claims vs India's medical device policy. Business Standard. Available from: https://www.business-standard.com/economy/analysis/setting-the-record-straight-ustr-claims-vs-india-s-medical-device-policy-125040700952_1.html
17. Production-linked incentive: empowering India's MedTech manufacturing landscape. Syrma Johari MedTech. Available from: https://syrmajoharimedtech.com/production-linked-incentive-empowering-indias-medtech-manufacturing-landscape/
18. SHARP - Piercing progress: innovating sustainable practices for IVF needle manufacturing. Vinnova. Available from: https://www.vinnova.se/en/p/sharp---piercing-progress-innovating-sustainable-practices-for-ivf-needle-manufacturing/
19. Make in India boosts domestic manufacturing of medical devices. The Sunday Guardian Live. 2025 May 30. Available from: https://sundayguardianlive.com/news/make-in-india-boosts-domestic-manufacturing-of-medical-devices
20. Indian pharmaceutical industry: creating global impact. ISPE. Available from: https://ispe.org/pharmaceutical-engineering/march-april-2025/indian-pharmaceutical-industry-creating-global-impact

21. India's transition to a circular economy towards fulfilling Agenda 2030: a critical review. Sustainability. Available from: https://www.mdpi.com/2071-1050/17/6/2667
22. Farlie F, Palmer GA, Cohen J, et al. Sustainability in the IVF laboratory: recommendations of an expert panel. Reprod Biomed Online. 2024;48(1):103600
23. Go green, go efficient: Sustainable laboratory practices — Lab Leaders/ Roche diagnostics article, June5, 2024. Available from: https://diagnostics.roche.com/global/en/lab-leaders/article/sustainable-laboratory-practices.html
24. María F. Manobanda-Lisintuña, Cristina A, et al. Carbon and water footprints within an environmental laboratory: Water, energy, and packaging management strategies. Green Analytical Chemistry, Volume 13, 2025.
25. Bayrau BA, Buyukcangaz E, Sadarangani SP, et al. (Un)Sustainable Science: Greening Practices in Research, Clinical Microbiology, and Veterinary Laboratories Locally and Globally. Open Forum Infect Dis. 2025;12(2):ofae677.

APPENDIX

Data collection—GREEN CRITERIA

Green criteria	*Compliant (points: 2)*	*Partially compliant (points: 1) describe briefly*	*Non-compliant (points: 0)*
Construction and design			
Solar energy panels in use or not Complete/partial load			
➢ Sustainable construction, like passive cooling strategies (with clay roof tiles, roof and walls painted with high SRI coating) building orientation and shading with overhangs, louvers, and trees			
➢ Energy conserving design (like large windows to tap natural light, sealed windows, etc.			
Is interior finishing sustainable or not (e.g., VOC-free paint)			
A rainwater harvesting system in place or not			
➢ Waste water-recycling being done or not (e.g. used water being used to wash cars, irrigation of the garden area, etc.)			
➢ Controlled water usage done or not: like low flow toilet systems, pedal operated scrub taps, etc.			
HVAC system—energy efficiency assessment ever done or not			

Contd...

Green criteria	*Compliant (points: 2)*	*Partially compliant (points: 1) describe briefly*	*Non-compliant (points: 0)*
Star rating of ACs, refrigerators, etc., checked to assess the efficiency of electricity consumption.			
Are smart energy solutions like LED lights and sensor smart switches being used or not?			
Admin and Clinical Workflow			
Paper-free clinic: ➢ Digital prescriptions ➢ Digital records ➢ Digital lab reports ➢ Others			
➢ Any recycled paper/alternatives like bamboo paper being used or not			
Admin and Clinical Workflow			
Quantify paper consumption per month			
➢ Plastic bottles/cups/cutlery ➢ Plastic files/folders/bags are being used or not			
Tele-consultation is being used and document the number of patient visits per IUI/OPU	>60%	30–60%	<30%
Are all stimulation injections being packed for administration at home to minimize scope 3 emissions?	>60%	30–60%	<30%
IVF OT and LAB			
Are reusable cloth scrubs, caps, masks, shoe covers, and patient drapes being used?			
Are SOPs in place to limit or quantify the use of consumables per patient per case?		X	
Is there a documentation of the average amount of culture media usage per patient per case?		X	
➢ Are cleaning agents used judiciously in the lab		X	
➢ Is there a practice to use eco-friendly cleaning agents?			
Is there a practice in your lab to cluster the freezing of gametes or embryos for a particular time in a day to minimize LN2 wastage?			

Contd...

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Green criteria	*Compliant (points: 2)*	*Partially compliant (points: 1) describe briefly*	*Non-compliant (points: 0)*
Are FETs being clubbed together to minimize LN2 wastage?			
Is cryo-storage space ideally located to minimize LN2 evaporation when extracted from cryo-cans for cryopreservation?		X	
Bio Waste			
Is there documentation and quantification of waste generated?		X	
Is color-coded segregation of waste being done or not?		X	
Bio Waste			
Is central sorting of biomedical waste being done or not?		X	
Is disposal of biowaste compliant with the standardized process?		X	
Procurement process			
Are local vendors preferred over distant/outstation vendors for equipment, consumables, injections, media, etc.?			
Are steps being taken to use 'Made in India' IVF products?	>60%	30–60%	<30%
Efficient inventory management SOP: "FIFO-FIRST IN/FIRST OUT" ➢ Is there a documentation of the order frequency of routinely used consumables, media, injections, etc?		X	
➢ Is there a documentation of wastage of unused/over-ordered material?		X	
Is there a conscious effort to ask the vendors to provide products in environmentally friendly and recyclable packaging material?		X	
Is there a process in place to check the ESG credentials or ESG reports of the vendors and procurement partners?		X	

Contd...

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Green criteria	***Compliant (points: 2)***	***Partially compliant (points: 1) describe briefly***	***Non-compliant (points: 0)***
Education and Audit			
Are there KPIs/SOPs for self-audit to ensure quality work in a sustainable manner with regard to the lab work and biowaste management?		X	
Are steps being taken to sensitize and educate patients, staff, and co-workers on sustainable practices?		X	
Has your center formed a Green Team to implement, monitor, and rectify green practices?		X	
Education and Audit			
Is there awareness of "Green Washing" at an individual or organizational level?		X	
Clinical management and reduction of cost burden Quantify as a percentage.			
➢ Use of adjuvant drugs	<30% cases	30–60%	>60%
➢ Min luteal phase support (using ≤2 progesterone preparations)	>60% cases	30–60%	<30%
How many fresh cycles are being done?	>60% cases	30–60%	<30%
Is single embryo transfer being carried out?	>60% cases	30–60%	<30%

INDIAN FERTILITY SOCIETY

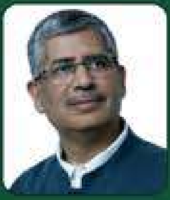
A Revolutionary White Paper

By The Indian Fertility Society For Sustainability in ART Practice in India and The Road Ahead

Prof (Col) Pankaj Talwar *VSM*, is a renowned Fertility Specialist and Director, Talwar Fertility and Men's Clinic, Gurugram, Haryana, India. Recipient of the Vishisht Seva Medal from the President of India, he has performed over 17,000 IVF cycles with a success rate exceeding 60%. A PhD in Embryology and pioneer of ovarian cortex freezing in India, he has established 29 ART units globally and trained over 2,500 gynecologists across 34 countries.

He serves as Academic Director, Clinical ART Program, SEART, Gurugram University; Dean, Department of Clinical Embryology, Shridhar University; Director, i-Ceat Academy of ART; Head, GE Healthcare 3D/4D Ultrasound Training School; and Advisor, DocInfra Solutions.

Author of 10 books and over 100 scientific publications, he is currently the President of the Indian Fertility Society (IFS).



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