CLIMATE ACTION BY & WITHIN IEEE

White paper

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DOI:

Cover picture – snowfall in the Sahara, Algeria, in 2022 – a sign of the effects of climate change

1. The complex interplay between climate change and digital technologies

The **impacts of climate change are everywhere**, from health [1] to migration, food security [2] to, more broadly, poverty. Climate change does not affect everyone equally – persons and communities who are already vulnerable suffer more due to the impact of climate change. Perhaps worse still, these impacts of climate change deepen the inequalities[3], since the vulnerable are least equipped to rebuild and reconstruct after the immediate catastrophes. The realities and impacts of climate change are receiving increasing attention the world over. Nowhere was this more evident than the 27th Conference of the Parties of the United Nations Framework Convention on Climate Change COP27) which purported to build on previous successes and pave the way for future ambition to effectively tackle the global challenge of climate change. The four goals of the Conference were linked to adaptation, mitigation, finance and collaboration. The issues of climate action are closely related to the Sustainable Development Goals (SDGs).

In "Climate change and COP26: Are digital technologies and information management part of the problem or the solution? An editorial reflection and call to action", an opinion paper published in 2021, scientists across ICT and management, from countries ranging from Lichtenstein to India, Saudi Arabia to Australia, Denmark to France, summarised their opinions as follows - "There exists a technical perspective to climate change where ICT has a role to play in the monitoring of potential solutions, but also an integral element of climate change solutions". Digital technologies are a part of the climate problem, with **"**concerns surrounding ICT waste management, energy management and emission management", while also being part of the solution, [enabling] "the integration of technology within the environmental management processes to improve performance." The IEEE's future position on climate action would be well advised to take this nuanced view of the interplay between digital technologies and climate change/action.

The recommendations of this work can also guide IEEE's future endeavours:

- Include environment as a key stakeholder in design and implementation of digital solutions.
- Focus on impacts of digital technologies on climate change, as well as benefits, adopting a "responsible" perspective.
- Research ICT in improving systems and processes in transportation, agriculture, and manufacturing industries to improve energy efficiency, reduce waste and deliver accurate data
- Strengthen the role of ICT in the provision of key data that can inform decision makers on the progress of global warming initiatives (e.g. using sensor based IoT technologies to alert authorities on emission levels)
- Create models and simulations within an overall sustainability framework that can encapsulate multi-level perspectives on the provision of data and technology interaction.

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[1] "On the current trajectory, climate change will become the defining narrative of human health" - 2021 report of the *Lancet* Countdown on health and climate change: code red for a healthy future.
[2] "Agriculture absorbs the disproportionate share of 63% of impact from disasters, with the LDCs and LMICs bearing the major brunt of these scourges." - Report in March 2021 by FAO
[3] Multidimensional inequality leaves vulnerable populations more exposed to climate hazards, more susceptible to the damages caused by these hazards, and less able to cope with – and recover from – these damages. This exacerbates inequalities further. UNDESA's 2017 paper – Climate Change and Social Inequality

Much recent research has turned its focus on the **role that digital technologies have played in aggravating climate change**. An equivocal 2022 article in Elsevier asked whether digital technologies and information management were part of the problem or the solution; and launched a call to action from us, the very members who contribute to the advancement of digital technologies and information management. Other reports on digital technologies worsening climate change are more categorical in their condemnation and we must take full cognisance of them. Compendia are beginning to emerge with resources on the impacts of digital technologies in the environment. The Royal Society made a more hopeful and forward-looking assessment, stating that **digital technologies can help tackle climate change**. In 2019, the International Telecommunication Union, ITU, published a report on "maximising the potential opportunities and minimising the downsides of ICTs" when it comes to climate change. In 2021, the Asian Development Bank ADB did a comprehensive analysis entitled "Digital technologies for climate action, disaster resilience and environmental sustainability". More subjective lobbying has been done through GeSI's "Digital with purpose" and DigitalEurope's "Digital action = climate action".

2. IEEE's actions relating to climate change and action

The **IEEE is increasingly important as a voice on the links - both virtuous and vicious - between climate change and digital technologies**, with the recent formation of an ad-hoc committee on climate by the Board of Directors, the Technical Activities Board's programme on climate change to support this committee – 42 members from 18 different IEEE Councils/Societies are active in four initiatives (Education contents and workforce development; Wildfire prevention, detection, prediction, and mitigation; Managing the food-water-energy nexus for sustainable development; Sustainable technologies - circular economy). In. 2021, IEEE Fellow Bruno Meyer participated in a panel during COP26 to discuss ways in which IEEE can help address the global climate challenges. There have already been fora dedicated to specific technologies and climate change – in 2021, the IEEE Future Tech Forum and in 2022, the Quantum Conference. In 2020, IEEE made an international call for standards to combat climate change. Finally, there is a dedicated portal for IEEE members on all things related to sustainability, "Sustainable ICT and sustainability through ICT". The IEEE Spectrum has been increasingly publishing articles describing technologies to address specific issues of climate change.

3. This white paper

This white paper hopes to further inform readers about the complex interplay between climate change and digital technologies, and identify the role IEEE and, more specifically, its technical bodies like CAS Society and Climate TAB can play, so that the "digital future rhymes with climate future". **The IEEE scientific community must use its technical expertise, global presence, and strategic influence to make sure that digital technologies contribute to climate action while also causing least harm.**

This **white paper is built on three pillars** –

1. The **evidence base of the interplay between digital technologies and climate**. On the one hand, *digital technologies contribute to climate change* through environmental degradation due to improper waste management, high-emission processes of fabrication, exploitation of natural resources, and high energy requirements for the operation of digital-driven processes like IT and electronics. On the other hand, *digital technologies contribute to climate action*, both mitigation and adaptation, through awareness and sensitization via digital media, environment management and energy optimization notably using sensor-based solutions, early warning systems to reduce impacts of extreme climate events, etc. Some elements of this evidence base are mentioned above.
2. The **IEEE's position as the leading global association of engineers and scientists of digital technologies**. Through over 500,000 members spread across 190 countries, its thematic and cross-cutting publications, its workshops and conferences, and its strategic and advisory roles, the IEEE can help spread awareness and good practices relating to the role of digital technologies in climate change and in climate action. Through its dissemination of cutting-edge digital solutions, IEEE can help design technologies that are at the forefront of climate action; and through its strategic and advisory position, IEEE can influence climate policy both nationally and globally. Some of the IEEE's initiatives related to climate action are mentioned above.
3. The first **IEEE Workshop on Electronics for Mitigating Climate Change** organized by CASS with the technical sponsorship of SSCS, EDS, SSIT, Sensor Council, and Nanotechnology Council, which took place in November 2022 in Singapore, in the hope advancing the contribution of digital technologies (including circuits and systems, electronics and telecommunications, sensors and actuators) to climate action. Just as importantly, the workshop stemmed from the necessity for us to consider how to not only positively contribute to climate action, but also reduce our harmful contribution to climate change. The wide range of geography and core competencies, as well as the varying stages of career advancement, among the participants helped illustrate how IEEE members can contribute to climate action, specifically as concerns health and food security.

Based on these three pillars, **this white paper presents**:

- Illustrations of digital solutions for climate action, relating to health and nutrition.
- Guiding principles for the digital technology community as relates to climate action.
- Activities that IEEE (CASS and beyond) could undertake pertaining to climate action.
- Suggestions for future workshops, to further increase its relevance and impact.

This **white paper is meant to be shared** as follows:

- It will be shared as is with the participants of the EmC2 workshop itself.

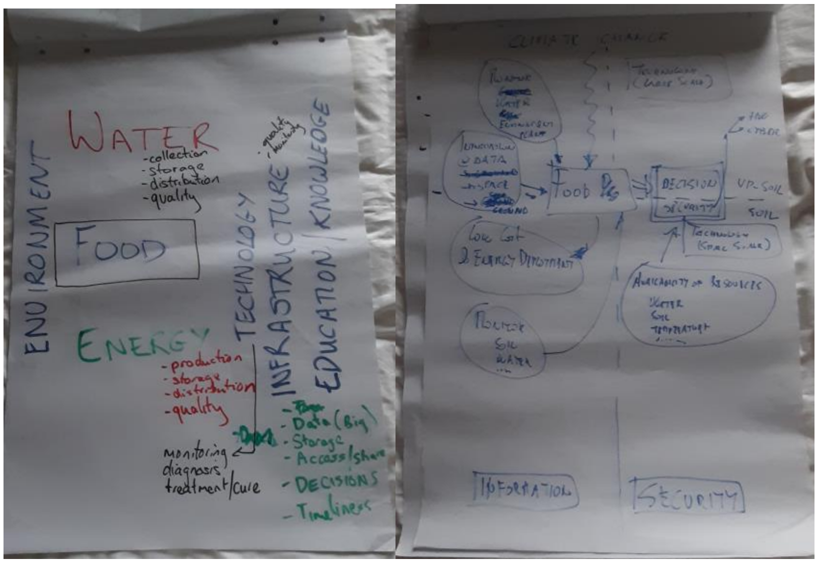
- An abridged version will be shared more broadly in CAS Magazine and on the websites of the CAS Society and Climate Action TAB.
- The white paper will also be accessible to the IEEE community at large.
- It is meant to inform the next edition of the EmC2 workshop, planned for Nov 2023
- It will also be part of the more strategic discussions of IEEE bodies to see what actions can be implemented.

4. Workshop Programme

IEEE's first EmC2 workshop took place in Singapore over 2 days, November 29th and 30th, 2022. The participants hailed from 10 countries – Italy, France, Spain, USA, Singapore, Japan, South Korea, Kenya, South Africa and Chile. They were a mix of people working in research laboratories and industry. The full list of participants is given in Appendix A.

Participants of the workshop

It opened with scene-setting by the chairs, followed by 4 keynotes. Participants then broke off into two groups, one on 'health' and the other on 'food' - poverty/economy and migration were interwoven into the two. Each group consisted of 10 members. The group work lasted two half-day sessions. The start of the group work was a recap of the takeaways from the plenaries, and then reflections on whether digital technologies are a menace to climate or solutions to climate-related problems. At the end of the group work, representatives of each group reported back in plenary. The workshop ended with closing remarks by the two chairs.



Some of the outputs of the deliberations in groups

One of the key outcomes of this workshop was a **deeper understanding of the three dimensions of climate action**.

- Mitigation:
    - Slowing the rate of the global warming
    - Can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing individual behaviour to reduce carbon emissions.
    - Any action which reduces our emissions or absorbs the carbon dioxide already in the atmosphere is a form of mitigation.
    - E.g. - Can help minimise climate change, so we don't get increasingly severe storms;
- Adaptation:
    - Taking steps to live with the effects of global warming
    - Refers to humans adapting to life in a changing climate and adjusting to the actual or expected future climate.
    - The goal is to reduce vulnerability to the harmful effects of climate change such as higher sea levels, more extreme weather events or food insecurity.
    - E.g. - Helps prepare for more severe storms we are already beginning to experience
- Resilience:
    - Becoming better able to withstand and cope with the effects of climate change

- A measure of an area's ability to deal with the effects of climate change and 'bounce back' or recover from an event like a storm or an extreme high tide if one occurs.
- Helps us bounce back more quickly following these storms.

5. Guiding principles for digital technology community on climate action [4]

The four keynote sessions were as follows:

- "Where digital futures support sustainable futures", Stuart White, Director - Institute for Sustainable Futures, University of Technology Sydney, Australia. The talk presented the impacts of climate change, notably in urbanisation, public infrastructure and water and sanitation systems.
- "Climate Change Effects in Healthcare & Public Health 2022 Dynamics", Luis Kun, 2022 IEEE President Elect for the Society for Social Implications of Technology, USA. The talk covered the entire range of climate-related disasters of these past years, as well as their impacts on human health.
- "How We as Engineers Could Address Climate Change", Leslie Field, Professor, Climate and engineering, Stanford University, USA. The talk addressed the timing and urgency of evaluating, testing, and potentially implementing localized and safe interventional solutions for climate-related issues.
- "Sustainable ICT technologies", Ravinder Dahiya, Bendable Electronics and Sustainable Technologies (BEST) Group, ECE Department, Northeastern University, Boston, USA. The talk covered the magnitude of e-waste, the ICT Footprint, Sustainable Technologies, and circular electronics.

The keynotes were varied and complementary – they presented the realities of climate change, as well as the complex interplay between digital and climate – on the one hand, digital technologies can help address climate challenges; on the other, there is a need for digital technologies to adopt paradigms that reduce their negative impact on climate. All the four talks were solutions- and practice-oriented.

The keynote speakers are variously placed - head of research body on sustainable development, digital entrepreneur-cum-researcher, head of research laboratory in digital technologies and scientific advisor to political decision-makers. Brief biographies of the Keynote speakers and short descriptions of their addresses are given in Appendix B.

[4] These emerged from the keynote addresses

Participants identified takeaways from the keynotes, which constitute **the ten guiding principles for the digital technology community as relates to climate action.**

10 guiding principles for the digital technology community as relates to climate action

1. Clearly understand the complexity of climate change and its impacts. Increase our capacity to articulate the three dimensions of climate action – adaptation, mitigation and resilience.
2. Promote a nuanced view of the link between digital and climate – digital technologies are real contributors to climate change and potential contributors to climate action. The pros and cons must be weighed against each other – while digital technologies can help understand and attenuate the impacts of climate change, they also contribute to climate change through irrational resource exploitation, improper waste management and energy consumption.
3. The digital technology community needs to “think global and act local” when it comes to contributing to climate action. This implies that the design of local and specific solutions must also be informed by the global trends and realities of climate change.
4. Consider the climate cost of producing electronics and electronic waste, and keep in mind the growing evidence base for the impacts of digital technologies on climate change. From this principle flows the promotion of technologies and processes that leave a smaller carbon footprint [1]
5. Take a ‘systems’ approach to solution design, which implies interdisciplinarity and members working with other disciplines, and looking at multiple disciplines and factors simultaneously and how they influence and impact on each other.
6. Ensure a closer interface with the key climate actors – policy, political and financial decision-makers – so that the technical solutions proposed by the IEEE communities are considered for climate action.
7. Account for the resource constraints in the settings for which the digital solutions are being designed, so that the solutions are realistic and efficient.
8. Promote the use of digital technologies in understanding the realities of climate change and in informing climate action. This includes collection, analysis and timely communication of data to relevant stakeholders. Related to this is the potential of digital technologies and data-driven Artificial Intelligence to help model climate change and develop Early Alert Systems.
9. Design solutions which are sustainable in the sense of ‘sustainable development’ – take an approach that promotes resource-effectiveness over resource-intensiveness of the digital technologies (in both fabrication and operation).
10. Communicate more effectively – democratise the understanding of the interface between climate action and digital technologies, and sensitise the population of the real potential of digital technologies to climate action.

6. Group work

One of the strengths of the workshop was the wide variety of profiles, competencies and roles of its participants. The participants were divided into two groups. Each group considered different social aspects of climate change - one health and the other food. As stated above, both these aspects are interlinked, both are clearly linked to poverty and inequalities, and both are push factors for phenomena like migration.

The group work consisted of four interrelated parts:

- Brief overview of the participants in the group; how each participant has been tuning his work to climate change or plans to do it.
- Discussions on specific climate-action projects, initiatives, and case studies that participants have come across in their professional capacities.
- The actions that each participant can take to increase the climate focus in their work
- How IEEE can better leverage its reach and influence for climate action.

In one group ('health'), more time was devoted to discussing the hurdles IEEE must overcome to be a real force on climate change; this was the natural course of discussions, due to the profile of the members of the group, which consisted of IEEE members with more decision-making power. The other group ('food security') delved more on very specific actions IEEE could take to become such a force. The report back from the group work exposed the complementarity of the two groups - hopefully, this will help strengthen the technical knowledge while also improving the context and conditions to apply this knowledge.

Group work in progress

7. Digital technologies for climate action in terms of health [5]

The 'health' group's deliberations emphasised the intrinsic interrelatedness of human health with other aspects – water, food, energy, health and medical technology, education and knowledge, and the environment at large. For instance, climate change impacts on health in that it may exacerbate existing health issues (e.g. more rainfall may lead to increases in vector-borne diseases such as malaria) and/or create conflict in the allocation of resources in future (e.g., funding and consumption of energy towards ageing and medical care for elderly). ICT solutions like biosensors, wearable medical devices and patient information systems need thus to be designed in concert with other disciplines.

Participants spoke of how digital technologies can help solve specific climate- and environment-related problems. One example touched upon air pollution, which has a certain effect on human health, but for which the collation and integration data to predict health issues or concentrations of pollutants is not well done. Thus, if data could be mapped into an aerial view of contamination, this could aid in more accurate diagnostics, correlation/causation of medical conditions, prediction of public health concerns, and improved land use planning and effectiveness of interventions e.g. tree planting and wind tunnels. This however requires influence on policy makers to lead integration.

Another example concerns vulnerability of – and access to - **patient information systems.** There is a gap in how health information systems are stored and integrated; medical providers do not have consistent systems and some are locally stored. This means that in a disaster situation (flooding, storm, fire, conflict etc), patient information may be inaccessible or lost, or effort and time wasted re-collecting information, potentially increasing death and injury. In terms of **wearable medical devices, notably for** elderly people, sensors already exist and are able to collect personal biometric data. But the gaps gaps are a) access is limited to those who can afford and are interested in adopting such devices and b) lack of integration into institutions and medical service providers.

So, while digital technologies do exist for health in contexts of the impacts of climate change, there are several barriers to adoption: mistrust in technology by physicians, medical administrators and patients; legal liability; low awareness and ability to use technology options by users and medical professionals. So, one core pre-requisite is for health experts to guide the development and deployment of digital health technologies.

8. Digital technologies for climate action in terms of food security [6]

The group adapted the session to have a more in-depth discussion on the factors and issues involved in one of the member's ongoing work involving precision agriculture in the Piedmont

[5] These solutions were identified from group work
[6] Idem

region of Italy. Climate change impacts on food production (and thus, food security) through pathways of water availability and soil quality.

This group too agreed on the fact that extra-technological factors determine whether and how digital technologies can contribute meaningfully to food security. These factors include – optimal design of the entire food supply chain and not only food production; scalability and adaptability of technologies to various agriculture contexts; and funding available for research, designing and deploying digital technologies.

Important technological considerations like dimensioning of sensors and their networks depending on the land use and bio-compatibility and bio-degradability of digital technology, have a clear impact on how electronics exacerbate climate change problems and need to be weighed against the real benefits of digitising food production and distribution.

Overall, there is a well-founded scepticism in the food and nutrition industry on using digital technologies and this can be overcome by educating these stakeholders about the good practices as well as involving them in the very design and deployment of digital solutions.

ICTs for food security can be envisioned at two interconnected, complementary levels – the higher/macro level ("above the soil"); and at the lower/micro level ("in the soil"). ICTs can be used to collect information from the lower level and use this information to make decisions that will ensure food security. Moreover, different parts of the world have different dimensions of food insecurity – in the developed world, the problem is more about quality and wastage, for which ICTs like tracking can be useful; in the developing world, the main problem is one of food quantity – ICTs like soil monitoring and satellite imagery can be used to improve yields. An additional dimension is that of distribution of food, from the areas of production/surplus to those of consumption/shortage.

9. Avenues of work for IEEE on climate action [7]

The **hurdles to IEEE becoming a leader in climate action** arise from several sources:

- Systemic issues within the IEEE: on the one hand, there are many silos in IEEE and on the other, a lack of clarity in strategy.
- Lack of clear understanding of climate change and climate action among IEEE members, which reduces efficiency of work, quality of discussions and increases the risks of greenwashing. The
- There is a disconnect between the cutting-edge, technologically-advanced solutions that IEEE members work on, and the impossibility of applying these solutions to those that need it most (bearing in mind that those worst hit by climate change are those who are already vulnerable and in low-resource settings).

[7] These solutions were identified from group work

- Difficulty for many (most?) IEEE members to envision or plan collaborations with other organisations, given, on the one hand, insufficient knowledge of each other's work and lack of resources to establish collaborations.

IEEE's contributions to climate action could be on three fronts, in view of its position as a technical exchange body, a lobby, a standard-setter, a platform for collaborations and a capacity-building organisation:

- Build a holistic view of digital technologies and climate change.
- Help promote technology and processes that leave lower carbon footprint.
- Enable new generations of engineers to act for climate action.

10 approaches and actions to Operationalise IEEE's contribution to climate action

1. Ensure that IEEE's future conferences and workshops expand participation to climate scientists, policy advisors, health professionals and agronomists.
2. Create spaces – within IEEE journals and conferences – to promote bio-compatible, bio-degradable, low-cost, low-power, high-usability solutions. This can be done via special editions of journals and special sessions in conferences.
3. Create a CASS sub-group to influence the IEEE's policy advocacy, in such a way that new climate policies take into account climate change, and vice versa. This will make CASS more involved in different IEEE bodies that work on policies
4. Create a CAS-specific or joint special interest group on climate change. This is important to illustrate across the IEEE the need and chance to work together on climate change.
5. Organise a cross-society joint workshop or conference on climate change in 2023, across different IEEE societies (tentative date - Sep 13-15 2023).
6. Establish a student design competition to encourage students to develop solutions to present in IEEE conferences. Such a competition is being considered for ISCAS 2023; if it does not happen, there is an embedded workshop on climate change at ISCAS 2024.
7. Start IEEE CAS students chapter (with SSIT) as a platform to increase awareness of impact of climate change on younger generations.
8. Look for collaboration with industry/govt to fund for technical skills to students to enable them to solve problems and design solutions and innovate matters in climate change
9. As conferences come back to being in-person events, there is an increased carbon footprint. So, study how to rationalise the number of conferences sponsored by CAS. Another approach is to encourage regional conferences so participants have to cover shorter distances.
10. That there needs to be leadership renewal within IEEE, with intergenerational collaboration and transmission, and a better use of social media and collaboration.

10. Recommendations for future editions of workshop

Participants provided **feedback on the workshop**, which will help guide the design of future editions of the workshop. The suggestions included:

- Host the social event before the start of the workshop so participants get to know each other before they are required to work in groups
- Continue to have keynotes which present a broader, social view and inspire discussions, but optimise the number of keynote speeches so that they do not take a disproportionate amount of the workshop programme
- Further broaden the range of keynote speakers, to include experts in policies or health, for example.
- Continue to have moderate-sized breakout groups, and continue to focus on specific topics like the role of ICT in health/food in view of climate change, topics which are of direct interest and relevance to participants
- Make this workshop a way to help break silos, by involving other societies like EMBS and Computer Society in the organisation of the workshop, encouraging members of these societies to participate in the workshop, identifying topics of common interest to all participating societies, and wider dissemination of workshop report.
- Ensure stronger participation from young engineers in the workshop.

Appendix A – Full list of participants in workshop

Name	Affiliation	Contact
Amara Amara	Terre des hommes foundation, Switzerland [CASS Past President, IEEE]	aamara@ieee.org
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Leslie Field	Professor, Stanford University, USA; Founder and head, SmallTech Consulting	leslie@memsinsight.com
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Stuart White	Director, Institute for Sustainable Futures, University of Technology Sydney, Australia	stuart.white@uts.edu.au

Appendix B – Biographies of keynote speakers and Abstracts of their addresses

Prof. Stuart White is Director of the Institute for Sustainable Futures where he leads a team of researchers who create change towards sustainable futures through independent, project-based research. With over twenty years experience in sustainability research, Professor White's work focuses on achieving sustainability outcomes at least cost for a range of government, industry and community clients across Australia and internationally. This includes both the design and evaluation of programs for improving resource use efficiency and an assessment of their impact. Professor White has written and presented widely on sustainable futures and is a regular commentator on sustainability issues in the media.

Abstract of Keynote - The fourth industrial revolution is having a major impact on the world. The combination of digital technology, mobile devices, artificial intelligence and the internet of things combined with other developments means that we are facing opportunities and challenges that are every bit as potentially impactful as the previous industrial revolutions starting with the era of steam engines and mechanical production in the 18th century. While there has been recent and appropriate scrutiny on the energy intensity of distributed ledger technology, and emerging ethical issues associated with some digital systems, e.g. artificial intelligence and facial recognition, there are significant opportunities for climate change mitigation arising from the deployment and integration of digital services. Nowhere is this more apparent than in the shift from linear and centralised utility systems and the emergence of decentralised energy resources which can have major

Dr. Luis Kun is the 2022 IEEE President Elect for the Society for Social Implications of Technology and a Distinguished Professor Emeritus of National Security (CHDS/NDU). Born in Montevideo, he holds a BSEE, MSEE, and PhD degree in BME, all from UCLA. He is an IEEE Life Fellow, a Fellow of the American Institute for Medical and Biological Engineering, the International Academy of Medical and Biological Engineering, and the International Union for Physical and Engineering Sciences in Medicine. He is the founding Editor in Chief of Springer's Journal of Health and Technology 2010-2020. He spent 14 years at IBM and was the Director of Medical Systems Technology at Cedars Sinai Medical Center. Dr. Kun received many awards including: AIMBE's first-ever Fellow Advocate Award in 2009; IEEE-USA Citation of Honor Award with a citation, "For exemplary contributions in the inception and implementation of a health care IT vision in the US." He served as an IEEE Distinguished Visitor for the CS and as a Distinguished Lecturer for the Engineering in Medicine and Biology Society and SSIT where he chairs the DL Program since 2016. Since 2014, he serves as an Honorary Professor of the Electrical Engineering Department at the School of Engineering of the University in Montevideo, Uruguay.

Abstract of Keynote - According to the World Health Organization, Climate change is the single biggest health threat currently facing humanity and the impacts are already harming health through air pollution, disease, extreme weather events, forced displacement, food insecurity and pressures on mental health. Extreme weather events in addition are causing greater damage than ever before, which affects both physical and mental health. The world faces many different risks from a large number of interconnected vulnerabilities that are generated simultaneously. This keynote paints a picture of the state of the world as concerns the impacts of climate change - a third of Pakistan is under water for months now; US farmers have to make decision in respect to what to plant and or to get rid of their cattle because of droughts; increased water levels in our oceans are causing people to flee from coastal areas to more secure ones, mostly urban areas. These moves increases population density which in turn increases the possibilities of spreading infectious diseases.

Dr. Leslie Field earned BS&MS degrees in Chemical Engineering from MIT, MS&PhD degrees in EECS from UC Berkeley, and has taught for 12 years on climate and engineering at Stanford University. She has since founded successful technical consulting businesses and climate-focused nonprofits. Dr. Field was the Project Lead of Micromechanics at Hewlett-Packard Laboratories to start a major MEMS R&D effort. At the second consultancy she founded, SmallTech Consulting, Leslie leads a diverse collaborative team working on MEMS and nanotechnology. The group has added to its original focus on biomedical devices, a significant focus on sustainable solutions for climate challenges. Dr. Field's nonprofit work has focused on climate change. She invented an approach for ice preservation, and then founded and ran Ice911 to collaboratively research, test, and model a localized engineering approach to slow ice melt, one of the far-reaching effects and drivers of global warming. Early in 2022, she founded and runs run Bright Ice Initiative, whose initial focus is on preserving and restoring glacial ice. The evaluations indicate that the approach has the potential to slow climate instabilities, to give the world a few more years of breathing room in which to urgently complete the transition to sustainable energy and fuels. Leslie's annual seminar course on Engineering and Climate Change at Stanford University, aims to provide the students a basis in understanding key climate forcers and feedback loops, and to promote an active approach of seeking to explore and develop effective solutions, through innovation and collaboration.

Abstract of Keynote - It has become increasingly and tragically evident over the past few decades that climate change is a pressing reality for increasing numbers of people around the world.
In this keynote speech, I will describe some of the key drivers and accelerators of climate change, and some of its key impacts on humanity and the species and ecosystems upon which we all depend. I'll give an idea of which kinds of climate change challenges must be addressed as rapidly as possible, and outline some potential solutions being researched. In developing potential solutions, we must remember to be inclusive, and to be sure that any interventions will not cause harm. Climate challenges are here now, and many of them are in someone's "back yard", so to speak. We must look to indigenous knowledge, and the people living closest to nature and the land, to be sure we include this expertise and wisdom in anything that we might consider doing in terms of intervention. We must work with transparency and permissions, and we must remember our connection to this earth, these ecosystems, and all the people and species we share this planet with, in order to create useful, viable, acceptable, and effective solutions to the world's most dire problems.
Over the past decade-plus, I've directed more and more of my work towards climate change-related challenges, especially towards preserving and rebuilding the icy reflectivity that historically has served to harmlessly reflect away solar energy. I and many others working on climate, have been working hard to preserve a habitable world for our children, and for the ecosystems and species on which we all depend. I've also been teaching at Stanford on Engineering and Climate Change for over a decade, because the next generations - will still have much to work on in their lives and careers, to address climate challenges. In this talk, I'll address the timing and urgency of evaluating, testing, and potentially implementing localized and safe interventional climate change solutions for some of the largest challenges humanity and our ecosystems have ever faced. I'll describe the challenges and accelerating positive feedback loops in the Arctic, and the challenges and importance of preserving glacial ice. I'll describe some promising solutions and work from around the globe that addresses a number of critically important climate challenges, and the large and inclusive framework we all must keep in mind in order to create viable solutions.

Prof. Ravinder Dahiya is Professor in Electrical and Computer Engineering Department at Northeastern University, Boston, USA. His group (Bendable Electronics and Sustainable Technologies, BEST) conducts fundamental research in electronic skin, flexible printed electronics and their applications in robotics, prosthetics, wearables, augmented/virtual reality and similar interactive systems. He has authored or co-authored more than 500 publications, books and submitted/granted patents and disclosures. Prof. Dahiya is President of IEEE Sensors Council. He is the Founding Editor-in-Chief of IEEE Journal on Flexible Electronics (J-FLEX). He has been recipient of EPSRC Fellowship, Marie Curie Fellowship and Japanese Monbusho Fellowship. He has received several awards, including Technical Achievement award from IEEE Sensors Council, Young Investigator Award from Elsevier, and 12 best journal/conference paper awards as author/co-author. He is Fellow of IEEE and the Royal Society of Edinburgh.

Abstract of Keynote - The miniaturization led advances in electronics during the last half century have revolutionized our lives through high-speed computing, communication and digital technologies - touching our life through almost all traditional sectors today (e.g., health, aerospace, manufacturing, and retail etc.). Yet, as revolutionary as micro/nanoelectronics technology has been, in its current form, it is not sustainable as it requires considerable resources for fabrication and leads to electronic waste at the end-of-life – for which currently there are not many attractive solutions. The current fabrication processes are inherently and unavoidably wasteful. For example, integrated circuits (IC) fabs rely almost entirely on subtractive manufacturing methods, leading to large material wastages and considerable adverse environmental impact. Clearly, there is a need for new resource efficient and environment friendly routes for electronics manufacturing and ICT systems. This talk will cover such aspects related to today's electronics and discuss few alternatives, including printed electronics, for the future sustainable electronic hardware. The talk will cover the magnitude of e-waste, the ICT Footprint, Sustainable Technologies, and circular electronics.