PANEL 1 SUMMARY

Image 1: Opening address by Professor Lily Kong, President, Singapore Management University

Image 2: Panel discussion session (from left to right) – Professor Thomas Schroepfer, Professor Barbara Norman, Dr Chen Song, Professor Yuan Chao, Professor Kristina Orehounig, Dr Srilalitha Gopalakrishnan, Dr Sergi Sauri.

1. **Role of Science of Cities in mitigating unprecedented challenges for planning and designs of resilient cities**

   In her opening address, Professor Lily Kong discussed the critical role of urban cities in mitigating unprecedented challenges: climate change, an aging population, and rapid workforce globalization. The key challenge of it all is the ever-changing feedback loops between diverse agents interacting in dynamic environments, which makes cities increasingly complex. This complexity necessitates multifaceted resilience strategies, including fostering discussions and initiatives for adaptable urban environments. She emphasised that there is an urgent need for proactive measures to address these challenges collectively – such as by leveraging science-based methodologies and collaborative efforts to tackle diverse challenges.

   Part of the urgency also lies in mitigating economic disparities in the design of resilient cities. Professor Yuan Chao, during a moderated panel discussion, recognised economic disparities as a critical aspect of building climate resilience, emphasising the challenge of ensuring equity for populations facing more frequent or intense climate risks. He highlighted that the vulnerable groups require targeted measures to address their specific needs. Dr Chen Song further elaborated about ongoing research efforts to understand the impact of heat on different demographics in Singapore (such as children, elderly, foreign workers), and the policy implications and need for regulations to address issues associated with health risks, such as heat stress and increased risk for dengue.

2. **With the growing complexity and diversity of climate change, there is a greater impetus to adopt an interdisciplinary approach.**

   "An interdisciplinary approach is essential to tackle the complex problems of cities, done by integrating insights from environmental science, urban planning and design, engineering and social science to develop comprehensive solutions."
   – Professor Thomas Schroepfer

   Professor Thomas Schroepfer, in his keynote address, highlighted the need for cities to be adaptable and resilient, and shared how the Future Cities Laboratory (FCL) in Singapore tackles this challenge through innovative projects in climate, food, health, and energy. He attributed the success of these solutions to the interdisciplinary collaboration efforts that allowed for aggregating a wide range of tools, knowledge and techniques to integrate science design, engineering and governance to create innovative solutions.

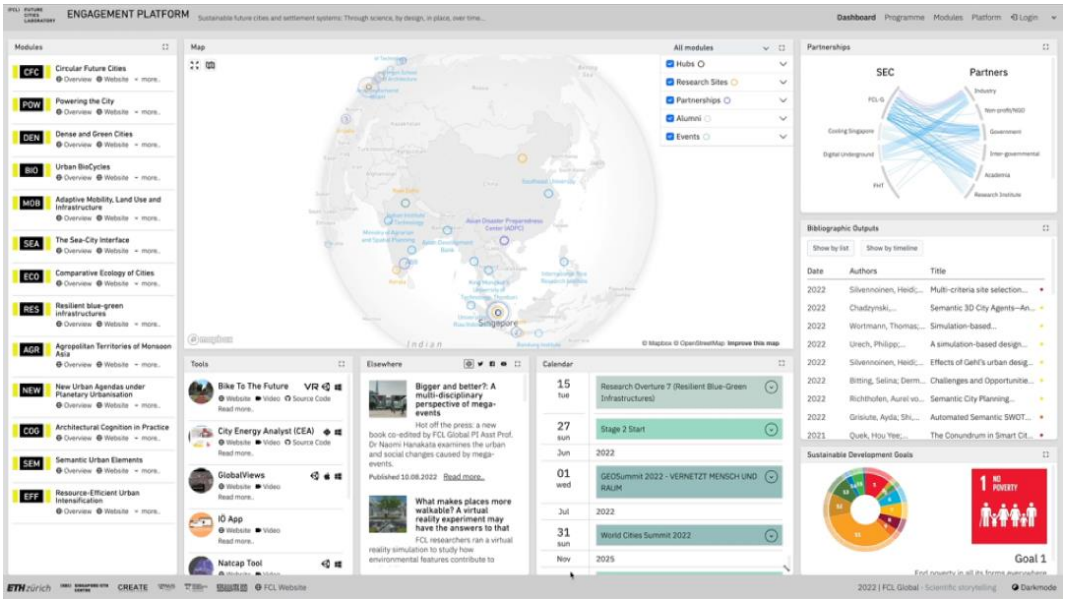

Image 3: Singapore ETH Centre's collaboration efforts across different countries, domains, and disciplines (from Professor Thomas Schroepfer's presentation slides)

Professor Barbara Norman concurred that effective solutions to tackle climate change issues must adopt *"a holistic perspective in considering equity, health and well-being as much as the salience of climate change"*. She stressed that efforts to mitigate climate change should be addressed at all levels, from global agreements to national policies and local regulations.

During the moderated panel discussion, Dr Chen Song similarly emphasised the importance of establishing a research community that brings together researchers from diverse backgrounds, government agencies, and universities. He argued that a collaborative environment can facilitate faster and more accurate information and tool sharing, enabling the community to work cohesively towards common goals. For the interdisciplinary approach to be effective, Dr Sergi Sauri and Dr Chen Song highlighted that it is essential to develop a common language for shared understanding. This may be in the form of using clear and consistent language during regular citizen engagement throughout project implementation and establishing public communication strategies to facilitate global engagement on the issues of climate change. Dr Srilatha Gopalakrishnan echoed these sentiments, and further suggested that there should also be alignment of ideas across disciplines. She cited FCL's approach of training employees in a 'common language' to ensure a shared understanding of information interpretation across different fields.

3. **There is a growing demand for finer-grained and predictive climate modelling tools to analyse the impact of climate change**

"Current forms of climate modelling is beautiful, user friendly and informative, but whether it is enough to help prepare us for the heat wave is not enough."

\- *Professor Yuan Chao*

Professor Kristina Orehounig emphasised the need for a multi-scale approach in policy formation to address the complexity of today's climate change. While island wide models measure overall impacts, district level models can pinpoint how policies affect specific areas. In the discussion of scales for analysis, several panel speakers highlighted the limitations of current climate modelling tools, and the need to develop tools that provide greater precision and pre-emptive analysis. They opined that climate modelling tools that were more attuned to a finer grain of analysis can examine the impact of climate change on people's everyday lived experience, while pre-emptive tools can anticipate the potential impact of any given action on the city's climate resilience.

For instance, Professor Yuan Chao highlighted the limitations of current anthropogenic heat dispersion models in providing the necessary resolution for precise analysis in identifying heat wave risk zones and climate modelling in Singapore. He emphasised the significance of considering terrain in heat wave simulation, particularly for low-density areas with steeper slopes, and proposed the incorporation of terrain data into simulations to achieve more accurate predictions of heat wave impact.

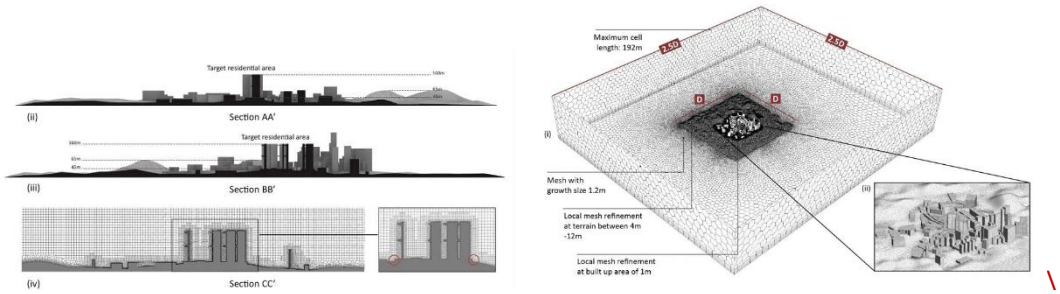

Image 4: Computational settings, boundary control and solver settings for the computation LES model of Natural Urban Terrain on Urban Wind Environment in High-Density Neighborhoods (from Professor Yuan Chao's slides)

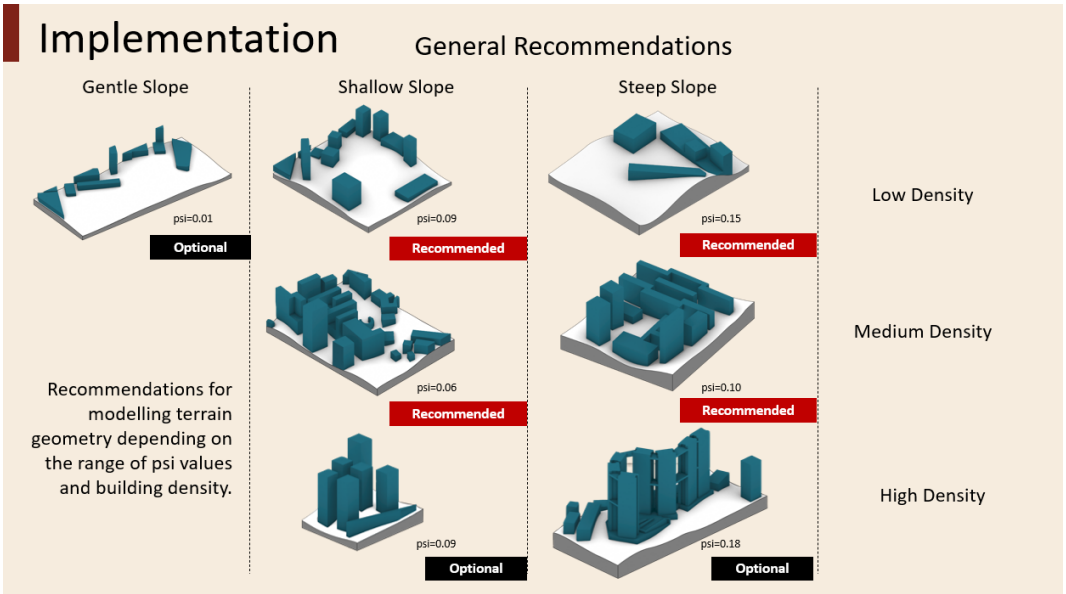

Image 5: Results of the computation analysis for the study on Natural Urban Terrain on Urban Wind Environment in High-Density Neighborhoods using LES model (from Professor Yuan Chao's slides)

Dr Chen Song advocated for a new climate modelling approach in response to Singapore's rapid warming and flood risks. He introduced uSINGV, a high-resolution system developed by the Meteorological Service Singapore, which incorporates an urban canopy model and offers higher resolution compared to the existing SINGV system.

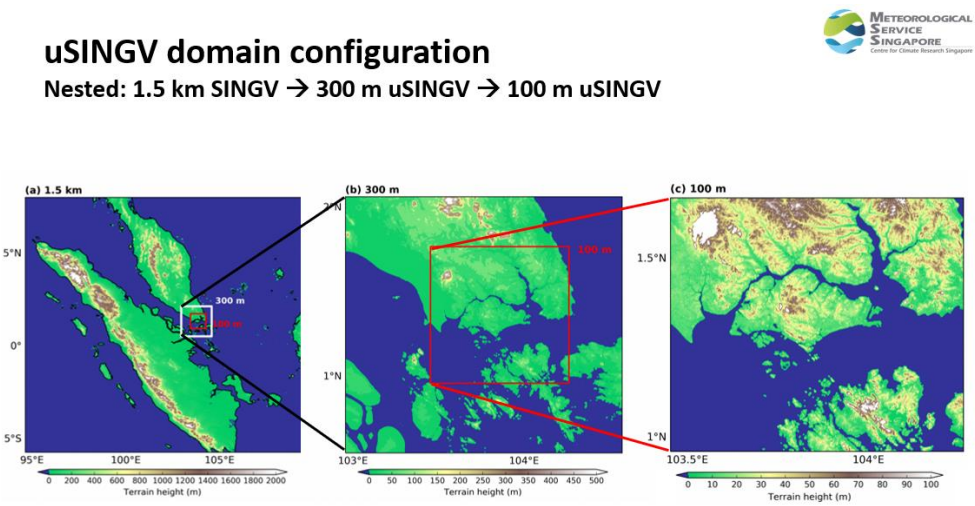

Image 6: Scale of analysis using the uSINGV model (from Dr Chen Song's presentation slides)

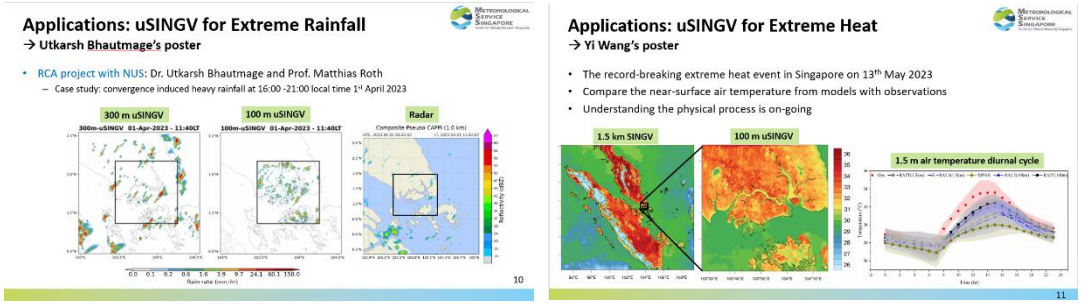

Image 7: Applications of the uSINGV model in climate modelling analysis (from Dr Chen Song's presentation slides)

Professor Kristina Orehounig presented the Digital Urban Climate Twin (DUCT), a collaborative effort between Cooling Singapore, academics and government agencies, to mitigate the urban heat island effect in Singapore. DUCT incorporates a wide range of datasets – such as island-wide vegetation cover, traffic patterns, weather conditions, heat emissions from industrial areas – and evaluates quantitatively what-if scenarios for future urban heat island and outdoor thermal comfort analysis at both district and island scales. It aims to aid academics and urban planners in developing design guidelines at the required scale of analysis, for instance, through use of virtual tools to help developers identify strategies to optimise district cooling systems in their building projects. The predictive analysis function of the DUCT model also allows researchers to simulate specified weather conditions, such as extreme heat wave, to anticipate how built-up areas in Singapore would fare under those scenarios.

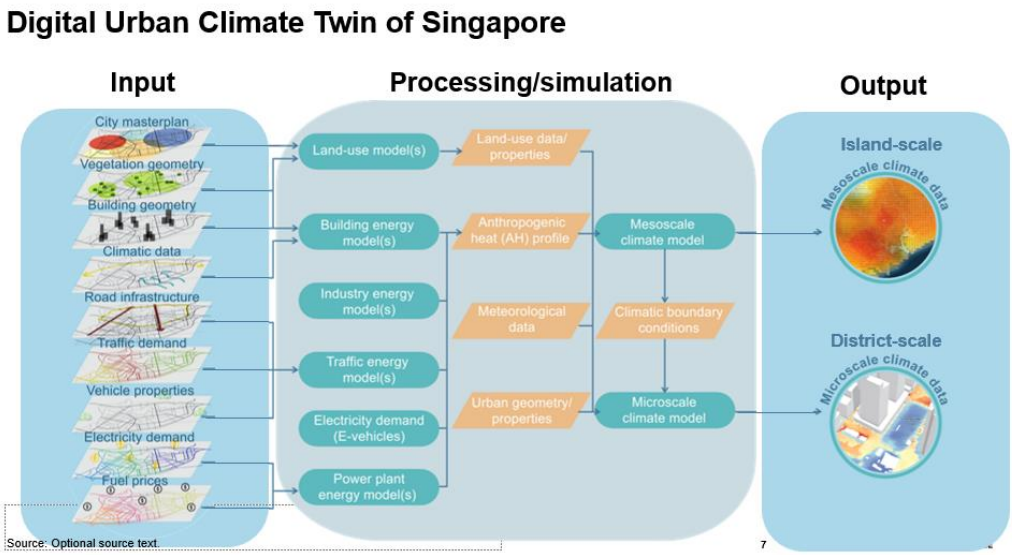

Image 8: Applications of the Digital Urban Climate Twin (from Professor Kristina Orehounig's presentation slides)

The panel speakers showcased diverse modelling tools used in studying climate change, particularly in the context of extreme climate events. While these tools are still in the process of refinement, they signify the potential to advance higher-resolution climate modelling in Singapore. The development of such tools will enable urban designers and planners to visualise the impact of future developments and formulate effective policies for sustainable urban development.

4. Climate resilience strategies shifting from people-centric, to *life-centric*.

"We are looking at cities to become a shared ecosystem, (with) a shift from people-centric to life-centric."

- *Dr Srilalitha Gopalakrishnan*

Dr Srilalitha opined that being climate resilience extends beyond being people-centric; it needs to take into consideration the diverse needs of the overall ecosystem – other living creatures included. In her presentation, she discussed the potential of skyrise greenery in enhancing Singapore's ecological networks and connectivity within neighbourhoods. She proposed a three-stage framework in analysing and quantifying network connectivity, mainly through mapping ecological nodes and edges, network analysis and performance evaluation. Dr Srilalitha highlighted the potential to scale up this methodology from individual buildings to entire neighbourhoods, paving the way to creating more sustainable and nature-integrated urban futures.

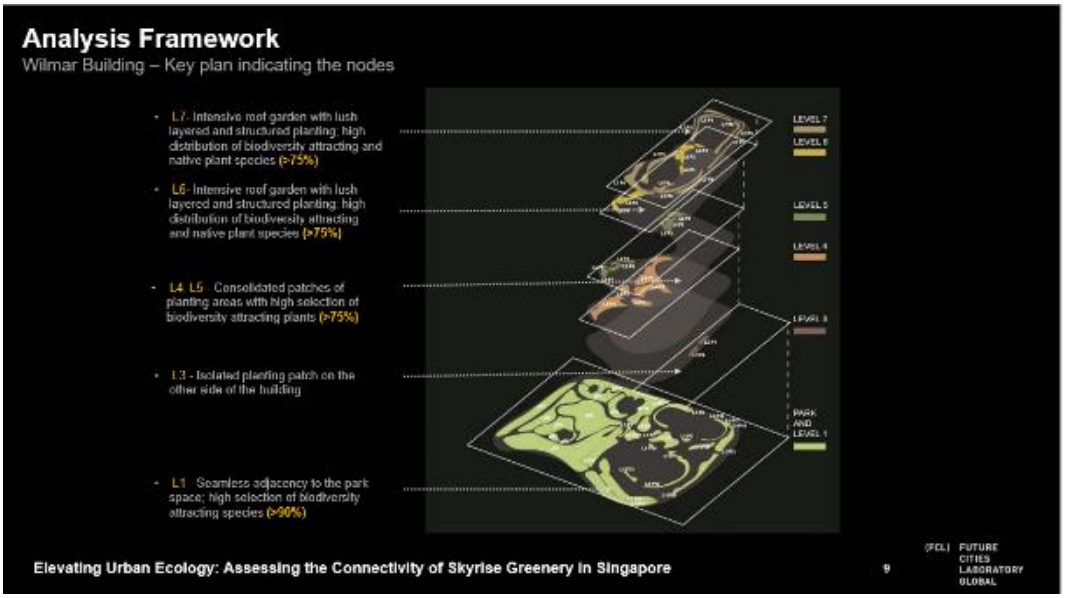

Image 9: Analysis Framework for skyrise greenery (from Dr Srilalitha Gopalakrishnan's presentation slides)

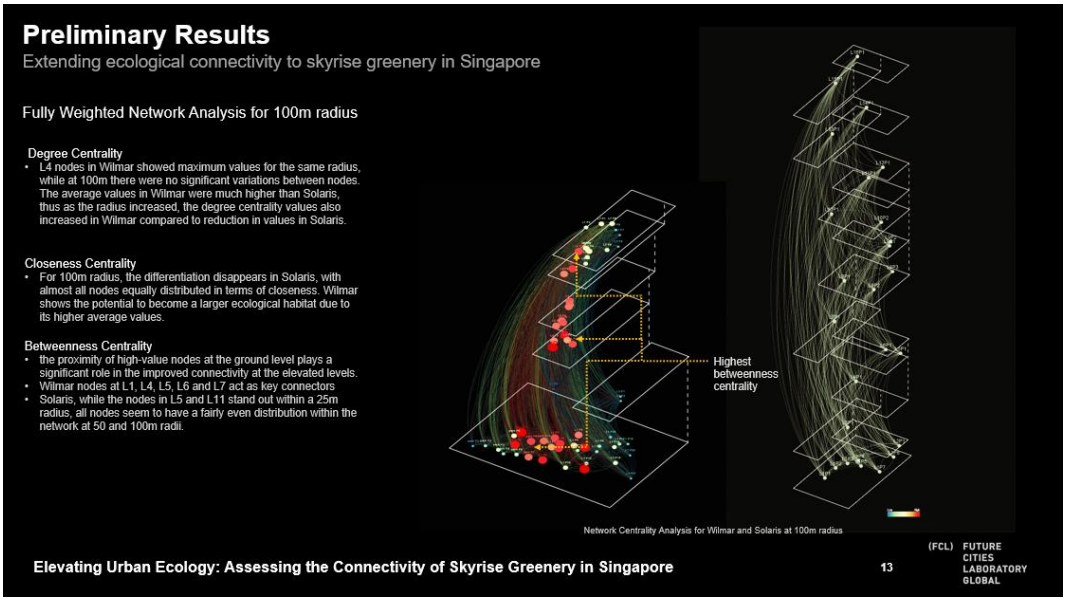

Image 10: Preliminary results of skyrise greenery connectivity (from Dr Srilalitha Gopalakrishnan's presentation slides)

To be life-centric, the panel also suggested that it is essential to engage at the community level to foster ownership and long-term commitment from city officials. During the moderated panel discussion, Dr Sergi Sauri emphasised the need to bridge the knowledge gap between research, government commitment, and citizen engagement. Government commitment should involve holding interactive meetings with citizens and engaging them throughout project implementation to foster trust and reassurance within the community.

5. **Beyond building climate resilience, there needs to be more conversations about the potential trade-offs associated with adopting climate-resilient solutions and how these trade-offs may be mitigated.**

"We try to talk about the combination of fiscal policies and mobility planning where there exists a trade-off between mobility and green spaces, and how to manage these externalities."

- *Dr Sergi Sauri*

Several panel speakers highlighted the potential trade-offs from climate-mitigating solutions, and the need to mitigate these trade-offs for the solutions to be effective. The lack of which, may render the solutions ineffective at best, or leave a negative impact in its wake. In Dr Sergi Sauri's presentation, he discussed the trade-offs between creating green areas and social mobility costs, using Barcelona's superblock network as a case study. This network prioritises pedestrian grids within green areas, resulting in positive outcomes such as increased economic activity and life expectancy. Benefits of the network were weighed against social mobility costs by simulating different scenarios and considering variations in the objective cost-benefit function. He underscored the importance of a balanced approach to green cities and the role of policymakers in optimising superblock networks by considering both environmental benefits and social mobility to create sustainable and equitable urban environments.

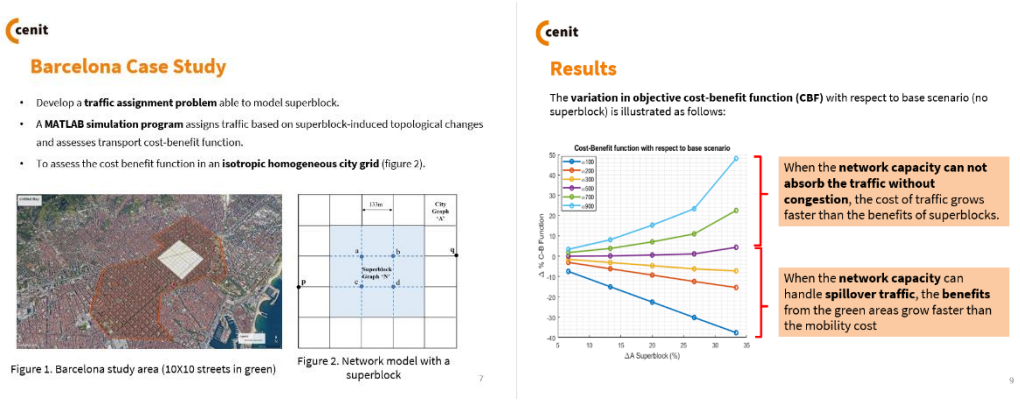

Image 11: Cost-benefit analysis based on Barcelona's Superblocks case study (from Dr Sergi Sauri's presentation slides)

The moderated panel discussion also stressed the importance of adopting a balanced approach to building climate resilience. The panel speakers acknowledged that Artificial Intelligence and Machine Learning can be powerful tools to enhance climate resilience. However, some noted that while these tools may offer speed and relative accuracy, the inherent lack of transparency in such technologies could raise concerns about the decision-making process.

Image 12: Group photo of presenters for Panel 1 (from left to right) – Professor Thomas Schroepfer, Professor Barbara Norman, Dr Chen Song, Professor Kristina Orehounig, Professor Yuan Chao, Dr Srilalitha Gopalakrishnan, Dr Sergi Sauri.