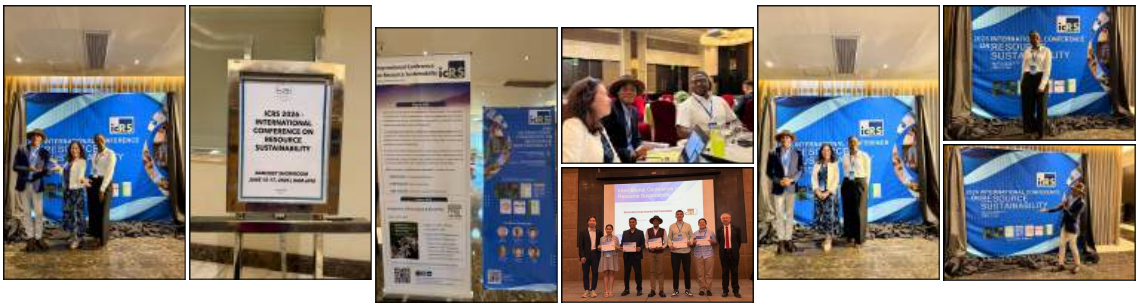
Sophia University at icRS 2026: Five Studies, Two Sessions, and One Award in Cebu



Four members of Sophia University's Graduate School of Global Environmental Studies traveled to Cebu, Philippines, for the 2026 International Conference on Resource Sustainability (icRS 2026), held June 15–17 at the Bai Hotel Cebu. The delegation included Dr. Nkweauseh Reginald Longfor, Assistant Professor at the Graduate School; Prof. Akemi Ori, Professor at the Graduate School; Marlen Kwamboka Mochoge, a master's student and JICA scholar; and Farai Maringa, a PhD student and MEXT scholar.

icRS brings together researchers from the natural sciences, social sciences, and engineering around a shared question: How should resources of all kinds, physical, biological, and those society tends to lose track of, like waste, be managed sustainably? The 2026 edition drew participants from universities and institutions across Asia, Europe, and the Americas, with sponsorship from the journal Resources, Conservation & Recycling (2024 Impact Factor: 10.9) and six other partner journals.

Across the three-day conference, the Sophia delegation presented five studies spanning solar panel waste management in Kenya, traffic and urban sprawl in Cameroon, waste-sorting barriers facing foreign residents in Tokyo, packaging governance in Japan, and a comparative assessment of municipal waste systems in Cameroon and Ghana. Prof. Ori and Dr. Longfor chaired

sessions of their own, and **Farai Maringa** left with an award.

Presentations from the Sophia University Delegation

All five presentations from the Graduate School of Global Environmental Studies were scheduled on Monday, June 15 — a full day that saw participants move between the morning and afternoon parallel sessions as both presenters and session chairs. Each presentation drew engaged questions and remarks from fellow conference participants.

1. Sustainable End-of-Life Management of Solar Photovoltaic Waste in Kenya: Implications for Circular Economy Transition

Presenter: Ms. Marlen Kwamboka Mochoge *(Master's Student, JICA Scholar)*

Session: Solar Energy | Chaired by: Prof. Akemi Ori

Kenya has been installing solar panels at a rapid pace as part of its low-carbon energy transition, but nobody has planned for what happens when those panels reach the end of their working life. Mochoge's study tackled that gap head-on. She modeled Kenya's projected PV waste volumes out to 2050 using Weibull distribution functions and found that the country could be sitting on more than 100,000 tons of accumulated panel waste by mid-century, with the sharpest increase hitting after 2040.

The more striking finding was economic. Mochoge tested three recycling scenarios: recovering just aluminum and copper, focusing on glass, or going after the full suite of materials including silver and silicon. The first two scenarios failed the cost-benefit test — the recovered materials simply were not valuable enough to justify the investment. The third scenario, full material recovery, cleared the bar with a positive net present value and an internal rate of return above 10%, even at a modest 20% diversion rate. Silver and silicon

drove the numbers.

The takeaway for Kenyan policymakers: partial recycling will not pay for itself, and without regulations tailored to PV waste, the country risks losing both the environmental and economic benefits that comprehensive material recovery could deliver.

Read the full abstract

The rapid expansion of solar photovoltaic (PV) systems in Kenya is central to Kenya's low carbon energy transition but is expected to generate significant volumes of end-of-life (EoL) PV waste as early installations reach retirement. Currently, Kenya lacks PV specific EoL regulations and waste management systems remain largely informal, raising environmental concerns and limiting the recovery of valuable materials such as silver and silicon. This study evaluated the scale and techno-economic feasibility of sustainable PV waste management options to inform evidence-based policy development in Kenya. Annual and cumulative PV waste generation from 2025 to 2050 is estimated using the Weibull distribution function on early loss and regular loss scenarios. A techno-economic assessment is conducted through Cost-Benefit Analysis of three EoL management scenarios: i) Partial recovery of aluminum and copper, ii) Glass-focused recycling, and iii) Full material recovery including silver and silicon. Capital and operational costs are adopted from international recycling benchmarks to the Kenyan context, while benefits are derived from values of recovered materials. In addition, interviews with key stakeholders and regulators are conducted to identify barriers and opportunities for PV waste recycling and to inform policy recommendations. Preliminary results indicate that cumulative PV waste in Kenya is projected to exceed 100,000 tons by 2050, with waste generation accelerating after 2040. Scenarios i) and ii) are not economically feasible even at high diversion rates mainly due to low value of recovered materials. In contrast, Scenario iii) demonstrates strong economic performance, achieving a positive Net Present Value and Internal Rate of Return above 10% at 20% diversion rate, primarily driven by recovery of high-value materials like silver and silicon. The finding highlights the importance of comprehensive material recovery to unlock economic potential of PV waste and target policy interventions to enable a circular economy transition in Kenya's solar energy sector.

2. Urban Sprawl, Functional Centrality, and Traffic Externalities in Central Africa: The Case of Yaoundé's Satellite Towns

Presenter: Dr. Nkweauseh Reginald Longfor *(Assistant Professor)*

Session: Urban Systems

Yaoundé, Cameroon's capital, pulls workers, students, and commerce toward its center while its population spreads outward into satellite towns that lack jobs and services of their own. Dr. Longfor's study measured what that mismatch actually costs — in equity, emissions, and money — for three satellite corridors: Soa, Mfou, and Mbankomo. The data came from 487 household surveys and 8,452 vehicle-trips logged across seven-day, multi-window traffic counts.

Nearly 78% of all trips along these corridors were mandatory — commutes to work or school, not discretionary travel — peaking at 92.5% in Mbankomo. Transport mode turned out to be shaped more by what each corridor offered than by personal preference (Cramér's V of 0.639). When the study controlled for corridor-level differences using progressively specified multinomial logit models, the estimated value of travel time rankings flipped: minibus VoT dropped from 6,809 to 2,822 FCFA per hour, while clando-taxi VoT rose from 3,907 to 7,133 FCFA per hour. Ignoring that correction would overstate aggregate congestion costs by 101%.

The equity picture was stark. The lowest-income commuters spent 40.3% of their income on transport and had zero access to personal vehicles. The highest-income group spent 10.9%, and 38.7% of them owned cars. On emissions, the study applied both IPCC Tier 1 (fuel-based) and Tier 2 (distance-based) methods and found a sharp divergence: 71,724 kg versus 29,476 kg of CO_2 per week, a ratio of 2.43 to 1 with non-overlapping sensitivity bounds — a structural gap, not measurement noise. The Soa corridor generated 60 to 71% of total emissions yet was the most efficient per passenger at 14.3 g CO_2 per passenger-kilometer, compared with 41.8 g on Mbankomo. That means blunt emissions-reduction measures targeting high-

volume corridors could end up penalizing the most efficient and lowest-income riders.

Dr. Longfor recommended decentralizing employment and services toward satellite towns, applying corridor-specific cost-benefit corrections, targeting fare subsidies to the lowest-income captive riders, prioritizing fleet renewal over service restriction, and adopting a replicable corridor-level monitoring framework for other rapidly growing African cities.

Read the full abstract

Rapid urban sprawl and strong functional centrality in African cities intensify compulsory commuting, congestion, and emissions, yet the equity and environmental dimensions of these externalities are rarely assessed together using corridor-resolved data. This gap limits the design of integrated land-use and transport policies for fast-growing peri-urban regions. This study examines how urban sprawl and functional centrality generate travel-behaviour and environmental externalities in three satellite towns (Soa, Mfou, Mbankomo) connected to the urban core of Yaoundé, Cameroon. Using household (n=487), driver, and seven-day multi-window traffic survey data (8,452 vehicle-trips), we compute a Functional Centralization (FC) Index, estimate progressively specified multinomial logit models of mode choice and value of travel time (VoT), and apply IPCC Tier 1 (fuel-based) and Tier 2 (distance-based) methods to estimate corridor-level tailpipe CO_2 emissions. Results show that 77.9% of trips serve mandatory purposes (peaking at 92.5% in Mbankomo), and that transport mode is strongly determined by corridor-level supply rather than preference (Cramér's V=0.639). Controlling for corridor reverses estimated VoT rankings (minibus: 6,809→2,822 FCFA/hour; clando-taxi: 3,907→7,133 FCFA/hour) and substantially improves model fit (McFadden R^2: 0.195→0.542; classification accuracy: 50.7%→78.4%), correcting a 101% overstatement in aggregate congestion costs. The lowest-income commuters bear a 40.3% transport cost burden with no personal-vehicle access, compared with 10.9% among the highest-income group, who report 38.7% vehicle ownership. Weekly tailpipe emissions diverge sharply by method (Tier 1: 71,724 kg CO_2; Tier 2: 29,476 kg CO_2; ratio 2.43:1), with non-overlapping sensitivity bounds confirming the divergence is structural rather than noise. The Soa corridor generates 60–71% of total emissions yet is the most efficient per passenger (14.3 g CO_2/passenger-km, against 41.8 g on Mbankomo), showing that emissions-reduction measures targeting high-volume corridors could inadvertently penalise the most efficient, lowest-income riders. We recommend decentralising employment and services toward satellite towns, applying corridor-specific cost-benefit corrections, targeting fare subsidies to the lowest-income captive riders, prioritising fleet renewal over service restriction, and adopting a replicable framework for corridor-level monitoring to support integrated land-use–transport planning in rapidly growing African cities.

3. Waste Separation Systems in Central Tokyo: Evaluating Linguistic and Structural Barriers Faced by Foreign Residents

Presenter: Mr. Farai Maringa *(PhD Student, MEXT Scholar)*

Session: Environmental Behavior

Japan's waste separation system is one of the most detailed in the world, but Maringa's research asked a pointed question: does the system actually work for the growing number of foreign residents who are expected to follow it? His study focused on Tokyo's 23 special wards, combining surveys of both foreign and Japanese residents with interviews of ward officials in three high-density wards — Shinjuku, Taito, and Minato.

The findings shifted the blame away from individual residents. Over half of the foreign respondents reported never receiving a formal waste separation orientation. Some never received guidelines at all because their building managers failed to pass them along. Ward officials themselves identified non-standardized rules across wards as a primary barrier to compliance — a structural problem, not a language one. Specific categories caused recurring confusion: oversized garbage that requires booking a pickup by phone in Japanese, and the line between recyclables and combustible waste.

Maringa applied the Cultural Theory of Risk to map how different residents approached the system. Some followed the rules closely (hierarchists), others adapted through community networks (egalitarians), some figured it out independently (individualists), and a fourth group felt overwhelmed and gave up (fatalists). His recommendations focused on structural fixes: coordinating rules between wards, creating direct communication channels between municipalities and residents that bypass building managers, and developing detailed visual guides for the waste categories that trip people up most.

Read the full abstract

This study evaluates the linguistic and structural barriers affecting waste separation compliance and understanding among foreign residents in Central Tokyo, also known as the special 23 wards. As Japan's number of foreign residents grows, municipalities face pressure to ensure inclusive governance for all essential services, including waste separation systems. Despite Japan's globally recognised waste separation systems, ward-level rule variations create significant adaptation challenges for foreign and domestic migrants alike. Employing a mixed-methods approach framed by the Cultural Theory of Risk, this research combines quantitative surveys of foreign residents with a comparative sample of Japanese residents, alongside qualitative interviews with ward officials from three high-density wards: Shinjuku, Taito, and Minato. Findings reveal that non-compliance extends beyond language limitations to fundamental structural flaws. Key barriers include: (1) non-standardized rules across wards, cited by officials as a primary compliance hurdle; (2) a broken information chain where over 50% of foreign respondents reported never receiving formal waste separation orientation and some not receiving waste separation guidelines due to poor communication from building managers; and (3) specific category confusion, particularly for oversized garbage requiring Japanese phone booking and separating recyclables from combustible waste. The Cultural Theory of Risk illuminates how compliance and understanding patterns align with four cultural worldviews: Hierarchist (compliant), Egalitarian (community-adapters), Individualist (independent), and Fatalist (overwhelmed). The study concludes that improving compliance requires a structural redesign of information and governance systems, moving beyond blaming residents or enforcing behavioural change. Recommendations include promoting inter-ward coordination, establishing direct municipal-to-resident communication channels to bypass unreliable building managers, and developing targeted and intricate visual tools for difficult waste categories. These insights contribute to sustainable urban governance literature and offer a transferable framework for global cities managing diverse populations while achieving environmental benefits such as increased recycling rates and reduced landfill use.

4. Toward a Governance Framework for Sustainable Packaging Systems in Japan: Institutions, Coordination, and Participation in the Circular Economy Transition

Presenter: Prof. Akemi Ori

Session: Sustainable Packaging

Japan has spent three decades building a recycling regime organized by material type — plastics go one way, paper another, glass another. Prof. Ori's study argued that this very success now creates a bottleneck. The material-by-material structure makes it difficult to coordinate across the full lifecycle of packaging, from choosing which material belongs where, to how products move through distribution, to how consumers participate in recovery. The circular economy requires that kind of cross-material thinking, and Japan's institutional setup was not designed for it.

The study built a three-layer analytical framework. The first layer examined packaging choices through a lifecycle lens, asking when plastic, paper, glass, or aluminum is the right material for a given use. The second compared Japan's institutional approach with the EU's regulation-led model, particularly the EU Packaging and Packaging Waste Regulation (PPWR). The third looked at how businesses, distribution networks, and consumers interact within each system. Prof. Ori also proposed a "breakthrough matrix" that sorts innovations into three types: technological, business-model, and collaborative.

Drawing on the Sophia University Sustainable Packaging Study Group — a platform of roughly 25 firms, regulators, and researchers — the study found that fragmented institutional arrangements were undermining system-wide coordination. Pre-competitive collaboration between firms and new business models mattered more than technology alone. And consumers, Prof. Ori argued, need to move from being passive sorters of waste into active participants in circular systems.

Read the full abstract

The global shift toward a circular economy (CE), driven by the EU Packaging and Packaging Waste Regulation (PPWR), the forthcoming UN Plastics Treaty, and 2050 net-zero commitments, requires packaging to be reconsidered not merely as a material artifact but as a socio-technical system shaped by institutions, industrial coordination, and public participation. Japan has developed a highly optimized, material-specific recycling regime over the past three decades. However, this institutional arrangement now constrains the cross-material coordination of distribution, consumption, and recovery required for CE.

This study addresses three research questions: (RQ1) what institutional and technological bottlenecks does Japan's material-by-material optimization generate in the CE transition? (RQ2) how can the principle of "right material, right place" be translated into an analytical framework and decision-oriented criteria informed by lifecycle considerations, distribution requirements, and institutional arrangements? and (RQ3) how does a Japanese model of co-creation-driven innovation complement the EU's regulation-led approach?

The study develops a three-layer analytical framework combining (i) a lifecycle-based perspective on cross-material packaging choices, (ii) comparative institutional analysis of Japan and the EU, and (iii) stakeholder-oriented examination of distribution systems, business-model innovation, and consumer roles, based on ongoing empirical observations and stakeholder engagement. It also proposes a three-type breakthrough matrix to organize sectoral innovations into technological, business-model, and collaborative dimensions. Empirically, the study draws on the Sophia University Sustainable Packaging Study Group, a multi-stakeholder platform involving approximately 25 firms, regulators, and researchers.

Preliminary findings suggest that fragmented institutional arrangements undermine system-wide coordination; pre-competitive inter-firm collaboration and business-model innovation are crucial for overcoming firm-level constraints; and consumers need to be repositioned from passive sorters to active participants in circular systems. The study proposes a governance framework for sustainable packaging systems in Japan and offers a theoretically grounded perspective on CE transition with implications beyond Europe.

5. Assessing Progress Towards a Circular Economy in Sub-Saharan Africa: A Comparative Evaluation of Municipal Waste Management Systems in Cameroon and Ghana

Presenter: Dr. Nkweauseh Reginald Longfor

Session: Circular Economy | Chaired by: Dr. Nkweauseh Reginald Longfor



For his second presentation of the day — this time in a session he also chaired — Dr. Longfor turned to a comparison of how Cameroon and Ghana are managing municipal waste. Both countries are members of the African Circular Economy Alliance, but the study asked how far each has actually moved from linear disposal toward circular resource management.

Using the Waste Management System Development Stage Concept (WMS-DSC) framework, the study scored seven components in each country on a five-stage scale ranging from basic system deficiencies to full circular economy implementation. Both countries remain at early transition stages. Ghana performed comparatively better in sector and market development, collection coverage, and selected recycling activities. Cameroon, on the other hand, showed stronger legal recognition of the waste hierarchy but weaker capacity to implement it. The gap between policy language and on-the-ground practice ran through both cases.

The study closed with targeted policy recommendations for each country, focusing on the steps needed to move beyond early-stage waste management and toward functioning circular systems.

Read the full abstract

Urban waste systems in sub-Saharan Africa are under increasing pressure from rapid urbanization, inadequate infrastructure, and growing resource constraints, yet empirical evidence on their transition towards a circular economy (CE) remains scarce. This study evaluates and compares progress in Ghana and Cameroon, two members of the African Circular Economy Alliance, in shifting municipal waste management systems from linear disposal-oriented models toward circular resource-management approaches. We apply a mixed-methods approach that combines literature review, field surveys, and semi-structured stakeholder interviews, and analyse these data using the Waste Management System Development Stage Concept (WMS-DSC). Seven components are assessed in each country: governance, sector and market, collection and transport, waste disposal, energy recovery, waste recycling, and prevention and reuse. Each component was classified on a five-stage scale ranging from basic system deficiencies to full CE implementation. Results show that both countries remain at early transition stages. Ghana performs comparatively better in sector and market development, collection coverage, and selected recycling activities, while Cameroon shows stronger legal recognition of the waste hierarchy but weaker implementation capacity. The study provides targeted policy recommendations for both countries, highlighting critical needs for advancing CE transitions.

Sessions Chaired by Sophia University Faculty

Beyond presenting their own research, Prof. Ori and Dr. Longfor each chaired a parallel session on Monday, June 15 — guiding the discussion, managing the floor, and fielding questions across a set of papers from researchers around the world. A review of the full conference program confirms that the three Africa-focused studies presented by the Sophia group were the only presentations addressing African countries or contexts across the entire icRS 2026 conference, underscoring the Graduate School's commitment to research on the African continent.

Solar Energy — Chaired by Prof. Akemi Ori

Prof. Ori chaired the Solar Energy session during the morning parallel block (11:00–12:20), bringing together four presentations that traced the photovoltaic lifecycle from manufacturing through end-of-life recovery. The session drew researchers from China, Kenya, and Belgium, and moved from industrial-scale recycling optimization to lifecycle assessment of emerging solar cell technologies.

The session opened with two papers from Taiyuan University of Technology in China. The first examined multi-entity synergies and spatiotemporal cost-

benefit patterns across different PV recycling modes in China, asking how heterogeneous recycling approaches interact as the country navigates the final stretch of its green energy rollout. The second applied a Stackelberg game framework to compare and strategically optimize hybrid recycling modes for retired photovoltaic modules.

The session's third presentation was Ms. Mochoge's study on solar PV waste management in Kenya (described in detail above), which brought a sub-Saharan African perspective to a session otherwise focused on Chinese and European contexts. The session closed with a study from Hasselt University in Belgium reporting lifecycle assessment results for scalable roll-to-roll manufactured flexible perovskite solar cells — a technology still moving from laboratory to commercial production.

Taken together, the four papers spanned both ends of the solar panel lifecycle and three continents, giving the session a scope that matched the global nature of the PV waste challenge.

Circular Economy — Chaired by Dr. Nkweauseh Reginald Longfor

Dr. Longfor chaired the Circular Economy session during the afternoon parallel block (16:00–17:40), overseeing five presentations that tested circular economy concepts against real-world measurement and implementation problems. The session ran in the same room where Prof. Ori had chaired the morning's Solar Energy session — a long day for the Sophia group in the Showroom.

The session opened with a study from Ghent University that stress-tested two widely used circularity indicators — the Material Circularity Indicator (MCI) and ISO 59020 — against bio-based products, asking whether tools designed for conventional materials hold up when applied to biological ones. Next, a team from the Indian Institute of Technology Tirupati presented a resource sustainability assessment of waste-derived warm-mix additives for asphalt-rubber pavements, connecting waste valorization to infrastructure applications.

The session then shifted to systemic and strategic perspectives. A study from Yonsei University introduced a "decoupled resource circularity" framework for analyzing how Sustainable Development Goal strategies are integrated into East Asian manufacturing — an approach that separates resource circularity from economic growth metrics. Researchers from the Technical University of Berlin followed with QuintESSENZ, a streamlined tool for product-level criticality assessment designed to make raw-material risk evaluation more

practical for industry use.

Dr. Longfor closed the session with his own presentation on municipal waste management in Cameroon and Ghana (described in detail above), rounding out a session that had moved from indicator design to material applications to national-scale policy assessment.

Outstanding Young Scientist Award

The conference closed on Wednesday, June 17, with an awarding ceremony organized by the icRS 2026 committee to recognize outstanding young scientists who presented during the three-day event. The award is designed to identify early-career researchers producing work of exceptional quality and to encourage the next generation of scholars in resource sustainability.

Farai Maringa, a PhD student at the Graduate School of Global Environmental Studies and MEXT scholar, was selected for the Outstanding Young Scientist Oral Presentation award. The recognition followed his presentation on waste separation systems in Central Tokyo, in which he demonstrated that non-compliance among foreign residents stems from structural and governance failures — non-standardized ward-level rules, broken information chains through building managers, and inaccessible booking systems — rather than individual negligence or language barriers alone. His use of the Cultural Theory of Risk to map distinct compliance patterns across resident populations offered a framework that extends well beyond Tokyo to any city managing waste systems across diverse communities.

Beyond the Sessions

Monday, June 15, was a long day for the Sophia group — four presentations across two parallel blocks, two sessions chaired, and sustained engagement with questions and discussion from fellow participants throughout. That evening, the group gathered for a team dinner to mark the day's work. All four presentations had drawn substantive questions and remarks from the audience, and the dinner was a chance to step back from the intensity of the program and reflect on how the day had gone.

On Tuesday, participants used the day to attend parallel sessions outside their own research areas and to connect with researchers from other institutions. The conference's plenary session that morning featured talks on AI for sustainability, circular intelligence in business models, and the promises and challenges of improving resource circularity through AI — themes that cut across the Sophia group's own work on waste systems, packaging governance, and urban transport. That evening, the icRS 2026 organizing committee hosted the official conference dinner at the BE Mactan Resort on Mactan Island. Participants were shuttled from the bai Hotel to the beachfront venue for an evening of food, conversation, and the kind of informal exchange that conference corridors and session Q&As rarely allow.

Wednesday morning brought the final parallel sessions, followed by the awarding and closing ceremony. After the conference wrapped up, Prof. Ori

organized a city tour that took the group through several of Cebu's historical and cultural landmarks: the Basilica Minore del Santo Niño, Magellan's Cross, the Cebu Metropolitan Cathedral, the Heritage of Cebu Monument, the Yap-Sandiego Ancestral House, the Taoist Temple, the Temple of Leah, and Sirao Flower Garden. Cebu is the oldest Spanish colonial settlement in the Philippines, and the sites traced roughly 500 years of layered history — from the arrival of Christianity and colonial rule through Chinese and Japanese merchant influences to the contemporary city. It was a fitting close to three days spent thinking about how systems, institutions, and communities manage change over time.





Looking forward

icRS 2026 is not only a venue for presenting research — the conference maintains partnerships with several peer-reviewed journals, and all participants were invited to submit full papers through the conference for recommendation to these partner publications. The partner journals include Resources, Conservation & Recycling; Resources, Conservation & Recycling Advances; Energy Economics; the Journal of Environmental Management; the Journal of Industrial Ecology; Sustainable Production and Consumption; and the Journal of Environmental Informatics.

Out of the five studies presented by the Sophia University group, three have been submitted through this channel and are currently under peer review. Once accepted and published, the findings will be shared on the Graduate School of Environmental Studies' website. Stay tuned.

For more information about the conference, visit the icRS 2026 website.