IIASA RESEARCH PROGRAMS' VISSIONS

Outlook Advancing Systems Analysis (ASA)

ASA builds on the extensive research legacy of its foundational components, which originate from four former IIASA programs that existed before 2021, and their unique expertise and synergies. With the reorganization of IIASA in 2021, ASA adopted a broad mandate focusing on innovation in systems analysis as a **meta-level approach** to understand complex socio-environmental systems and provide decision support for addressing associated management challenges of policy and practice. Within this mandate, we focus on

- common patterns in organization and dynamics (e.g., networks, complexity, stability);
- common management concerns (e.g., enhancing systems resilience, facilitating transformation, ensuring cooperation, decision-making under uncertainty); and
- common methods for analysis across multiple systems (e.g., agent-based modelling, game theory, optimization, Earth observation, risk analysis)

across various systems, pertinent to IIASA's overall mission, such as energy systems, food systems, production systems, etc. Our focus on common aspects across various systems complements research in other IIASA programs that delves into the specifics of individual systems. This integration of system-generic and system-specific research, with seamless opportunities for cross-fertilization between the two, embodies IIASA's unique strength and highlights the essence of systems analysis as a comprehensive approach to understanding the world around us. The ASA self-assessment report for 2021-2024 highlighted numerous examples showcasing how ASA leverage this approach to make significant contributions to informing and scientifically grounding 'wicked' problems that require policy and practice intervention.

Following the reorganization of IIASA in 2021, ASA devoted considerable effort and resources to establishing new and novel arrangements that **fostered fresh collaborations** and **sparked innovative research**. Now, with these new processes and structures fully operational, including research groups and within- and across IIASA-group teams, we are well-equipped to further cultivate innovation and impact in line with our mission. Beyond 2024, we aspire to build upon the work conducted in 2021-2024 and continue driving innovation within our core focus areas. Furthermore, we aim to **push the boundaries of our research and activities in several critical and innovative directions**, including the following.

Unveiling the shared properties of complex systems and governance principles, to enhance systems-based understanding of the world, improve our ability to manage 'known unknowns', and better prepare for 'unknown unknowns'. This research will contribute to the advancement of General Systems Theory. A key focus area is the analogical modelling of digital (platform) economies as complex adaptive systems, sharing fundamental characteristics with natural ecosystems – such as the synergistic creation of value by

multiple agents, emergent phenomena, and innovation as a driver for evolution and adaptation.

Exploring resilience for responding to the evolving landscape of interrelated systemic risks. We aspire to focus on methods and models for addressing the polycrisis involving the combination of climate change, biodiversity, geopolitics, digital divides, etc. This requires new approaches to assessment, decision-making, and governance for addressing multiple, interacting crises and seeking to identify options for building resilience across systems and scales, which, also building on ongoing work, will require new modi operandi for engagement, such as labs for co-production and experiential learning for IIASA groups and relevant stakeholders.

Understanding the heterogeneous socio-economic impacts of the combination of 21st century's biggest trends—decarbonization, digitalization (including AI), and geopolitical decoupling. First, we will further advance and apply participatory foresight techniques, utilizing systems thinking, to produce future scenarios, extending beyond what can be extrapolated from the past. Second, we will further develop our agent-based modelling approach towards creating digital twins of our socio-economic systems to evaluate impacts on various segments of the population taking into consideration their heterogeneity and bounded rationality. These modelling efforts may also involve humans interacting with a gamified interface within the digital twin, allowing for the elicitation of realistic behavior strategies that can be integrated into the modelling process.

Improving environmental monitoring using new data sources (e.g. low-cost sensors, wearables) and AI. As a particularly promising direction, LLMs provide a unique opportunity to significantly improve the quality of image recognition, necessary for translating Earth observation through remote sensing into meaningful environmental indicators, such as land use type or degree of urbanization, heat islands, pollution hot spots and loci of high vulnerability.

Improving 'social' monitoring using new data sources and AI. New data sources derived via internet searches (e.g. Google Trends), gamification, or social media (e.g. X, Facebook, TripAdvisor) can be used for eliciting a variety of behavioral patterns and social responses across various challenges (e.g. purchasing habits, mobility, disaster management and climate risk responses).

Enhancing horizon-scanning activity. As a cross-cutting-focused program at IIASA, ASA is naturally positioned to undertake horizon-scanning efforts to 'discover' new methods and new applications of existing methods for the benefit of ASA research and IIASA's scientific community beyond ASA. We will continue and intensify ASA open seminars which proved to be an effective way to learn about new developments and foster knowledge exchange.

Further enhancing work with policy and practice (NGOs, development banks, private sector, etc). Science-informed decision-making requires partnerships with implementing entities. As a general principle, we will continue to expand such partnerships as necessary in our specific projects. As one particular activity, ASA has been and will continue to play a crucial role in the establishment of the Raiffa Center, which aims to bridge the gap between diplomats engaged in collaborative policy development, scientists conducting relevant research, and stakeholders to the policy decisions.

Lessons learned and selected elements of plans for 2026-2029 (Biodiversity and Natural Resources - BNR)

BNR mission is to provide insights and knowledge that promote global and regional systemic transformations toward **sustainable integrated biosphere management and human wellbeing**. This mission is delivered by the Program as a whole and each individual Research Group. At the Program level, we will continue with flagship products development as successfully initiated under the 2021-2024 Research Plan:

1. **Integrated Biosphere Management Modeling Framework (iBIOM)** together with its **cyberinfrastructure (Accelerator)**. Adequate funding has been generated for model integration across groups and work is in good progress, infrastructure prototypes are already available too. For 2026-2029 stable version releases and mainstreaming with clients and collaborators are planned.
2. **Global Biosphere/Biomass/Bioeconomy Outlook**. Baseline development and reporting templates were achieved, benefiting from Accelerator development. An outlook light – iBIOM baseline released on **Accelerator supported intuitive web interface** is planned for 2025/2026, in parallel possibilities for a full-scale stakeholder-driven and adequately-funded Outlook are being explored.

And we will newly put emphasis on additional areas:

3. **Integrated Biosphere Management Database (dBIOM).** The possibility to consolidate and release the detailed harmonized database underlying iBIOM as an additional service to the global research and practitioners community will be explored.
4. **Climate extremes and adaptation.**
5. **Capacity building** to support the development of a large and competent iBIOM user and collaborator community.
6. **Geographical presence.** While BNR research has a strong presence in some regions, such as Europe or China, it is less active in other strategic regions, particularly **Africa**. BNR will pursue new funding opportunities to enhance its outreach in regions with high challenges to sustainable development and high needs for system analysis tools.

AFE Group stands for the creation of relevant and insightful scientific knowledge and policy insights in understanding global and regional primary production and management on land focused nature-based climate solutions.

1. Complementing cutting-edge assessments of **agriculture management** under climate change with novel scientific tools combining cropland modelling systems and data-driven AI methods for sustainable food systems and a healthy environment.
2. Leading in **global forest modeling** at multiple scales through integrating climatic niche effects (albedo, CO2 fertilizations, soil carbon, etc.) and linking with natural

disturbance- and other land use models within BNR to identify sustainable forest management options. Focus put on a wide range of nature-based and natural climate solutions including for the built-up environment supply chains and other CDR options to condemn future climate overshoot.

3. Leading the field of integrated **wildlife-forest ecosystem management** through scale- and geography-independent modeling of forest-wildlife interactions under climate change.
4. Cutting-edge risk assessment of **natural disturbances**, including wildfires, bark beetles, and windstorms in multiple ecosystems through dynamic model linkages, using advanced technologies, such as AI, Network Analysis, and earth observation. Expanding wildfire understanding through socio-economic impacts to ensure healthy and resilient communities and ecosystems at a local and global scale.
5. Adopting novel technologies including CDR, electrolyzes, and advanced synthetic fuels like Hydrogen with special emphasis on **optimal spatially explicit and dynamic supply chains** including sustainable transportation systems at multiple scales and geographies including also BIMSTEC, and Africa.

The **BEC group** develops and applies state-of-the art ecological knowledge, methods, and tools to **understand ecosystem functioning, ecological responses, and feedbacks in coupled social-economic-ecological systems**. The group applies its knowledge and tools to **investigate appropriate management options to achieve sustainability goals that have ecological implications.** In the period 2026-2029, the BEC group will focus on the following research areas:

1. **Integrated spatial planning,** to identify where and how land and water could be managed to better support biodiversity conservation objectives. BEC will increase its focus on **ecosystem restoration, for policy support towards the implementation of the Nature Restoration Law and Kunming-Montreal GBF Target 2.** This will also be an emerging topic in the context of future nexus scenarios of climate mitigation and adaptation, land-use and biodiversity change.
2. On the topic of **One-Health,** BEC will investigate which ecosystem attributes (e.g. functional composition, food web properties) affect the **likelihood of infectious disease emergence and spillover from animals to humans**.
3. The group will continue its research on **biodiversity scenarios**, expanding its scope to **sustainable cities and peri-urban green and blue infrastructure.** BEC will provide the needed ecological understanding and models of biodiversity responses and ecosystem service provision (e.g. pollination, health risk mitigation) for impact assessment and trade-off explorations of alternative management scenarios of the built environment and its surroundings.
4. **Biodiversity indicators**. The BEC group will design and apply indicators that **better capture changes in the state of biodiversity and ecosystem services, as well as response indicators**, related for example to protected areas

representativeness and effectiveness, that could be adopted for monitoring post-SDGs targets.

5. BEC will grow its research efforts on **biodiversity and finance,** with potential topics including models and indicators to **track multiple-scale impacts of supply-chains** (e.g. on food and other raw commodities) with the view to **support biodiversity-related financial disclosure initiatives**.

The **WAT group** aims to undertake **research, innovation, and capacity building** to provide a sound scientific basis for strengthening the policies, investment and action needed to enhance current and future water security. To accomplish its mission, WAT research will focus on three core activities:

1. WAT will enhance its contribution to ongoing global efforts on **integrated assessment of water resources availability, quality, and demand**. WAT has already facilitated several integrated water resources assessments across global-to-local scales under future global change scenarios using the CWatM hydrological Model. WAT will further strengthen its assessment capacity by completing the ongoing improvements in CWatM of several **key natural and human-influenced water processes** (e.g., irrigation, reservoirs, wetlands, wastewater, etc.), covering explicitly **water quality aspects** (e.g., nutrients, temperature, etc.), building linkages to other BNR models (e.g., GLOBIOM, Plant-FATE, G4M) within the iBIOM framework for a better assessment of water-related sectoral impacts, developing **post-processing tools and visualizations** for a better communication of our results taking advantage of the BNR-Accelerator infrastructure, and leveraging new **Earth Observation products** for better model evaluation. The assessment of **hydro-climatic extremes**, e.g., droughts, will be further improved by assessing risks and impacts of extremes and identifying the underlying causes of vulnerability using advanced data analytics and policy assessment methods.
2. WAT will strengthen its research on exploring **transformation pathways toward a water secure future**. This entails identifying implementable solution options and fostering their diffusion and scalability by adopting a transdisciplinary approach (combining modeling and governance tools) and involving relevant stakeholders across sectors and institutional scales. WAT will especially focus on investigating the full potential of innovative options such as natural water retention measures and circular and decentralized water management. To do so, we aim to complete the development of the multiscale version of the ECHO hydro-economic optimization model.
3. WAT aims to extend its **capacity building activities** (e.g., CWatM Summer School) in terms of content and learning methods towards building a strong user community of WAT tools.

IBF group's mission is to provide **scientific insights as well as direct support to decision makers** with respect to **transformations in land, water, and ecosystems**

management that promote **integral human development** while ensuring **sustainable use of natural resources** at the **national, regional, and global scale**.

The developments over the last years brought about, or made more obvious, new realities, such as:

1. Businesses realized that the future economy will be largely a bio-based economy, and demand comprehensive assessments of biomass availability and its future prices.
2. Economic and social implications, real or perceived, of environmental policies led in many countries to a rise in populism and thus jeopardized the sustainable development agenda.
3. Climate extremes and geopolitical developments challenge established supply chains.
4. Technological solutions alone will not suffice to bring the planet within a safe operating space.

In order to continue to deliver on its mission, **IBF will boost its research along four axes**:

1. Fully integrate the **blue economy** into the sectorial economic model GLOBIOM in order to achieve comprehensive coverage of food and biomass resources.
2. Boost the capacity to assess the **economic, social, and financial implications** of environmental policies to enhance the acceptability of the latter.
3. Mainstream **climate extremes, natural disturbances, and adaptation**, as well as the **geopolitical developments** into the baseline scenarios.
4. Explore novel sustainable development pathways relying on **transformative behavioral change**, going beyond diet change.

Future Energy, Conservation and Environment (ECE) Research Activities

We have identified seven clusters of future research activities for the ECE Program. These aim at advancing the understanding of climate mitigation and adaptation strategies, leveraging digital solutions, promoting justice and equity, and enhancing policy relevance of our work. Many of the activities span across several of the ECE Groups and would foster further collaborations with other IIASA Programs.

1. **Managing the overshoot and accelerating the transformation**

Greenhouse gas emissions are continuing to rise, and global warming is exceeding critical thresholds such as the goals of 1.5C of the Paris Agreement. This poses a whole new set of research questions of how to manage this overshoot, provide a better understanding of the reversibility of impacts and the feasibility of society to draw down warming once it has peaked. Future ECE research activities in this area would integrate:

- International governance challenges related to overshoot, including the creation of new markets for removal of CO2 from the atmosphere
- Systematic exploration of deep decarbonization opportunities to accelerate the transformation, particularly through new granular demand-side provisioning systems. This would include moving towards a better understanding of the role of infrastructure in enabling carbon-free choices, given heterogenous social norms and individual preferences (mobility and buildings).
- Portfolio of *sustainable* CDR options (with limited trade-offs for other objectives, such as biodiversity)
- Residual emissions of hard-to-abate sectors that would need to be offset through negative emissions options - in particular identifying realistic non-CO2 emissions reduction potentials from the agricultural and industrial sector.
- The potential of the hydrogen economy to support a renewable based system, and its atmospheric feedbacks for the climate and air pollution

2. **Integration of impacts, mitigation and adaptation**

Traditionally, climate impacts and adaptation are studied in isolation. To provide a better understanding of climate futures, ECE will integrate the two dimensions in a holistic framework. This is critical for understanding how climate impacts affect the overall socio-economic development path as well as the capacity to mitigate and to respond to climate change. Four core areas of research comprise:

- Improve the understanding of biophysical and economic climate impacts and risks with particular focus on key risks, extreme events, climate overshoot, and tipping elements, and an enhanced integration of climate impact drivers along the climate impact chain.

- Advance frameworks for climate resilient development pathways. This includes the development and application of novel methodologies for an integrated assessment of climate impacts, adaptation, and mitigation, including stress testing.
- Development of pathways of adaptive capacity as part of the SSP framework including sectoral applications.
- Progress from climate attribution to climate accountability. Develop an interdisciplinary research agenda of linking emissions to climate damages, with a particular focus on climate inequalities and inequities.

3. **Digitalization and AI**

It is critical to understand the role of digitalization and AI as a major enabler of sustainability transitions. Digitalization can create new services and thus raise the environmental footprint of society. At the same time it can also foster planetary stability by reducing material and energy needs. There is a wide range of new disruptive digital end-use innovations, such as, integrated mobility and housing systems that may improve the quality and efficiency of the service provisioning systems. Research in this area will study new digitalization pathways and the relationships among digitalization, equity, political agency, and planetary stability.

From a methodological perspective, ECE will further integrate AI and machine learning approaches in its modelling tools. Initial areas will include the forecasting of sectoral service demands across heterogeneous population groups, as well as the downscaling of the global IAM scenarios to more granular spatial scales at the country and sub-national level.

4. **Circularity and Built environment**

Circular economy principles in construction and urban planning can significantly lower the demand for raw materials, thereby decreasing the environmental footprint. Particularly important in this context are innovative low-carbon building materials (such as, nature-based construction) as they may sequester carbon and create co-benefits for various other SDGs. Relevance of this topic is exceedingly high in the Global South where much of the infrastructure and built environment is yet to be created. ECE research in this area will focus on:

- Deepening the understanding of the potential of circular economy strategies to contribute to climate change mitigation and pollution
- Exploring the potential for storing carbon in the built environment, including wood-based construction, innovative low-carbon building materials (including exploration of potential trade-offs, such as for biodiversity)
- Understanding the role of urban planning and architecture in adaptation and mitigating climate change
- Development of bottom-up waste management strategies, identifying co-benefits across the SDGs (plastic waste, buildings, materials)

- Understanding vulnerability of energy systems and the transformation process towards a low-carbon economy, including the role of critical materials, import dependence, supply chains and the role of demand to moderate vulnerability

5. **Air pollution - health and ecosystems**

Air pollution and its impacts on human health and ecosystems remain on the agendas of developing and developed countries. While successful implementation of air quality and development policies managed to decoupled pollution levels from economic growth in many regions, a lot still needs to be done to attain healthy levels of exposure. Better understanding of impacts and various co-benefits of integrated policies across scales and domains (air quality, biodiversity, climate change) would also support and enable long-term transformations needed to stay within planetary boundaries delivering on many SDGs and reduce costs of mitigation. ECE will further advance and focus on:

- Extending the ECE modelling framework to include air pollution impacts on morbidity, indoor pollution, and biodiversity, including, to the possible extent, its economic dimension. This will link to the broader assessment of 'costs of inaction' providing improved and inclusive representation of costs of air pollution in respective frameworks.
- Addressing pollution and mitigation strategies in cities (also from the regional perspective) will support the broader work on urban environments, connecting dimensions of pollution with development, equity, built environment, climate change and adaptation.
- Improving representation of ozone. Regional and urban ground-level ozone has been increasing in many regions of the world, which is linked to a combination of successful aerosol focused strategies as well as increasing global CH4 concentrations. New and improved tools will allow for a better integration/alignment of strategies and policies across air pollution and climate domains to address this challenge.
- Extending and harmonising approaches and data for mining and processing of minerals and metals needed in deep decarbonization futures. Spatially explicit distribution of production and assessment of pollution impacts as well as equity dimensions will provide important insights on health as well as supply-chain vulnerabilities.

6. **Justice and Equity**

Justice and equity are central to sustainable development and climate mitigation efforts. Research in this area will focus on the integration of multiple dimensions and patterns of justice into just transition pathways, including:

- Exploration of different ethical principles and how they are reflected in international as well as national laws. This area of research will include the development and application of new justice concepts (e.g., carbon dept concept) for deriving equitable distribution of mitigation burdens and the impacts of climate change (across regions,

actors, and including disadvantaged groups, such as indigenous people as well as interspecies equity).

- Gender-specific impacts of climate change will be explored, aiming to develop strategies that address the unique vulnerabilities and contributions of different genders to climate mitigation and adaptation.
- Provide a better understanding of energy and material requirements of decent life (base on bottom-up and empirically derived definitions of social and physical well-being).
- Integrating multi-dimensional inequities across mitigation, sustainable development, and pollution impacts.
- Supporting the international policy process by providing estimates of fair finance according to different definitions of "differentiated responsibility"
- Explicit integration of (above) justice and equity considerations into the ECE integrated assessment modelling framework

7. **Enhancing policy realism and policy relevance**

Providing sound policy advice requires to capture salient relationships between individuals, societies, markets, and government institutions, and how these relationships shape the production, distribution, and consumption of resources. Research in this area will aim at improved representation of underlying social, behavioural and political heterogeneities. This will include:

- Improved representation of distributional effects of policies (across households, sectors and regions)
- Improved presentation of countries, but also cities as agents of change in global IAM modelling. This will include an improved representation of multilevel governance and related solutions that often require coordinated efforts across different governance levels.
- Empirical research (and surveys) to better understand "lifestyles" in terms of consistent behaviour and potential bifurcations in society in response to climate policies.
- Exploration of the political economy of fossil fuels phase-out and enabling conditions for, eg, effective waste management
- Improved representation of the finance sector as a potential enabler of transformation processes.
- Development of policy-roadmaps for low-energy-demand futures at city, country, and regional scale. The roadmaps would explore how to achieve high levels of wellbeing with low energy and material use (following the "High with Low" narrative, see the ECE report).

- Science for policy making. ECE will further strengthen its role and contribution to development of local and regional policies addressing newly defined health and biodiversity objectives using risk based approach and community targets with explicit consideration of various equity dimensions.

Economic Frontiers – Vision 2025-2030

1 Starting point and lessons learned

Over its initial 2021-2024 period, EF has put in place three modelling frameworks to study (i) **optimal dynamic decision-making in the presence of disruptive (regime-changing) shocks** (2SOCS); (ii) the impact of **transitions/policymaking on behaviours and outcomes** within and across overlapping generations of **heterogeneous households** (MIWAG); and (iii) decision-making of **heterogenous actors in risky environments** (MODIBE). The objective over the next five years is to apply the frameworks more broadly to practical policy questions and to harness policy impact. This is also with a view to strengthening engagement with NMOs and other global actors (World Bank, OECD, etc) and forming the basis of internal and external collaboration.

2 Fields of continued engagement

Around the modeling frameworks a research agenda has emerged on the impact of socio-economic-environmental transitions on heterogenous populations and decision-making in disruptive contexts. We anticipate further engagement along these lines with a focus on **(1) positive and negative disruptive and/or tipping events**: natural, social/political and technological; **(2) model-based metrics and measures:** Resilience; Value of Information on disruptive processes; Social cost of carbon (SCC); asset valuations; Value of Statistical life (and its relation with e.g. SCC); value of population; **(3) Socio-economic gradients** in behavioral responses and outcomes **under transition processes:** climate policy transition (MULTIFUTURES – 2024-2027); food-system transition (Archimedes Centre; in planning); transition of built environment; **(4) Health and health care:** socially-graded long-term behavioral responses to climate-induced health stress; climate-related infectious disease systems (SI: Eco Health); **(5) Dynamic economic modelling** of transition processes and policymaking: Regional coal phase out (JUSTCOAL 2023-2025) and other transitions.

3 New directions

Based on the EF modelling frameworks and additional capacity within the program we see potential to develop research into the following emerging topics:

Nature-finance nexus: With newly acquired expertise in (climate) finance, EF will integrate and/or add financial economic approaches into its research themes. One particular focus will be on the linkages between (non-traded) natural capital that is subject to pollution/climate risk and traded assets that either rely on natural capital (eco-system

services) and and/or cause such risks. Based on its 2SOCS framework EF will derive model-based asset valuations from the perspective of different decision-makers (e.g. social planners as opposed to private investors) to understand what are optimal investment *and* disinvestment strategies from a portfolio perspective and how policy-making can correct financial market bias.

Transition of the built environment and regenerative economy: EF could add several perspectives: (i) The impact of urban transitions on heterogeneous populations could be studied within the MIWAG framework when extended for "housing assets"; (ii) the transition towards a regenerative bio-economy could be studied within the regional transitions models; (iii) EF could employ vintage modelling of the housing stock to understand how an urban planner should structure the building transition over time, taking account of market structures and population change. Both (ii) and (iii) would benefit from EF capability in the economic modelling of material cycles.

Maintaining incentives to act and containing inequality in the age of overshoot: Projected temperature overshoot endangers economic, health and survival prospects. In so doing it also changes expectations and beliefs as drivers of individual action towards climate mitigation and adaptation and towards investing in human capital. By shortening the time horizon and increasing the effective discount rate, a riskier environment and poor prospects lower expected returns to investments. EF would study how (possibly distorted) beliefs, information and preferences interact with a decision-maker's constraints in stifling or fostering willingness to engage/invest. Such analysis can be cast both within the 2SOCS framework (for understanding decision-rules) or within the MIWAG framework (for understanding heterogeneity in prospects and choices) and inform policy makers on how to preserve incentives through incentives, information and communication.

Governance of transitions in a world of power and conflict: The transition to a regenerative economy will involve large-scale reallocation of wealth and opportunities and thereby generate unprecedented scope for backlash and conflict at all scales. The scope for conflict is leveraged by the presence of disproportionately powerful private and public actors who may well pursue stand-alone agendas. Appropriate governance structures to avoiding, resolving or neutralizing these conflicts and addressing power asymmetries have to be integral to any implementation strategy towards a transition. EF has modelling capacity for studying these issues in terms of contract theory, public economics, advanced dynamic game theory, and the modelling of criminal systems. Such work could feed into the Raiffa-Center Initiative and the OECD Strategic Partnership.

Role of AI (and technology more generally) in environmental and socio-economic transitions: AI is acknowledged as a key technology in enabling the net zero transition and safeguarding eco-systems. At the same time the question as to how, when/where and by whom AI is developed and deployed has direct implications on the environment (through

energy and resource intensity) as well as on the socio-economic system through large-scale replacement not just of tasks but of human capabilities. The advent of AI is prone to change human capital investment and capabilities with a risk of exacerbating socio-economic and educational gradients. These issues can be studied within existing EF frameworks (e.g. the 2SOCS framework applied to technology change and the MIWAG model).

All of these topics are touched upon by at least some of the other IIASA programs and research groups and EF will **seek opportunities for co-development**. EF's key contribution to the development of any of these themes (and others) will lie in its expertise in the modelling of (i) **endogenous** (economic) **behaviours as the outcome of optimization** on the part of **heterogeneous decision-makers; (ii) integrating** these **behaviours** into the dynamics of **aggregate outcomes** and the **distribution of wellbeing;** and (iii) deriving **policy-rules and the underlying valuations** in complex dynamic settings.

4 External and internal capacity building

External: Based on a **continued open modelling** strategy, EF will undertake efforts in (a) engaging in capacity building (directed at mostly scientific communities due to the relative high technicality of our models); (b) deriving simplified applications and tools; and (c) developing modeler communities.

Internal: To support the applications of the existing modelling frameworks, EF will strengthen its **empirical capacity** with a view to calibrating models and carrying out self-standing empirical analysis on topics of interest. A farther-reaching ambition is the **integration into EF research of deep/reinforcement learning** based (optimization) techniques and **machine-learning algorithms to complement and enhance more conventional econometrics**. For this, we will initiate a gradual process of capacity building by inviting and engaging with experts in this field and inviting them to collaborative work based on EF frameworks and collaborating with other IIASA programs with similar development interests. An additional step will be through the recruitment of relevant expertise.

5 Internal, external and NMO collaboration

EF will pursue further its **collaboration with other IIASA programs** wherever this is conducive and feasible. Ongoing and developing initiatives include inter alia the project PVARGLOBIOM (BNR), the Special Initiative Project Eco Health (BNR, POPJUS, ASA); joint work with AFE on model integration at the micro-macro-interface; work on health and climate (POPJUS) as well as any joint initiatives on new IIASA fields of research. The **network on "Modelling resilience and disruptive changes"** will be further developed

and a **similar network on "Transition impacts on heterogeneous populations"** will be developed. Amongst ongoing collaboration, EF will strengthen its role in new areas, e.g. its panned participation in a **network on Social Tipping**. It is also developing research plans with the US NMO, the Archimedes Center and Viet Nam and is in active exchange with the Iranian NMO. It also plays a role in the development of the **Raiffa Center**.

6 Funding

EF will continue to pursue its **balanced funding strategy** on scientific grants. Based on modelling applications it will seek to expand into more policy-oriented, larger-scale funding (e.g. from EU directorates), as well as into network-based funding with a view to opening larger-scale (e.g. philanthropic) funding. It will also direct initiative towards collaborative and/or policy-oriented project funding from NMOs. EF is open to IIASA-wide (larger)-scale funding initiatives, contributing state-of-the-art economic modelling wherever this is conducive.

Population and Just Societies

Overall, the vision and strategy for 2021-2030, as developed in 2021, is solid and holds up well. However, a few points from our POPJUS perspective could be added or edited, as detailed below concerning the official document. These suggestions are based on consultations with Josephine Borghi (SHAW RG), Roman Hoffmann (MIG RG), and Thomas Schinko (EQU RG).

In general, POPJUS will take a bold approach, envisioning how future societies can thrive amid the challenges and constraints we face today—and how these might evolve over time—as shown on the figure below. This strategy is anchored by three key pillars:

- How can we tackle inequities as a crucial step toward sustainable development? By embracing justice principles rooted in the cutting-edge framework developed by the EQU research groups, we will explore the way for a fairer, more sustainable future.
- Grasp the escalating impact of climate change on health—including on healthcare systems—and migration, and unlock the key drivers that enhance the capacity to adapt and thrive.

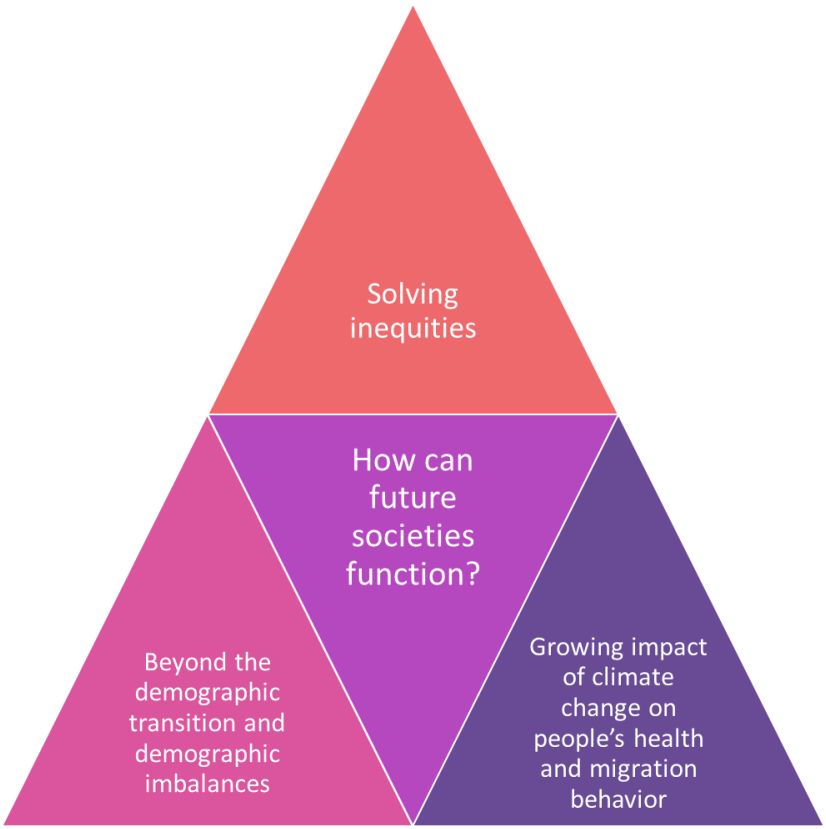

Figure: Graphical representation of the POPJUS approach and its three pillars

In more detail:

Within this Research Theme (**Population and Vulnerability**), it would be critical to emphasize future health research, particularly as the SHAW RG will be intensifying research along three main axes:

- Understanding the effects of climate change, environmental factors, and other global shocks on health and wellbeing across the life course.
- Investigating how climate and other stressors impact health systems, including the people, institutions, and resources that deliver essential health services.
- Evaluating the effects of policy responses—or the lack thereof—on health, wellbeing, and health systems, with an emphasis on sustainability and resilience.

Another strand of research that will be developed is that on migration with a focus on enhancing the understanding of human mobility in times of global changes and transformations:

- Enhancing the analysis of the effects of climate change on human populations and their implications for migration across different regions and population subgroups.
- Exploring the role of multi-hazard and compound events and crises in shaping migration patterns. Studying the complex relationships between diverse risks across time and space and their relevance for mobility outcomes.
- Explicitly considering, quantifying, and modeling immobility and the multiple reasons for why people stay put despite potentially difficult circumstances.

Within the Research Theme **Biodiversity and ecosystem services**, and based on the ongoing and planned work of the EQU Research Group, it would be important to add two strands of research:

- Identify governance innovations for enabling Nature based Solutions (NbS) to tackle the interconnected climate and biodiversity crises systemically;
- Co-develop and investigate just and viable pathways for transformative change towards reducing biodiversity impacts of major value chains.

Enhancing impact, it would be important to mention that we will also explore the possibility to support scholars who are at risk because of war or civil unrest.

In terms of **capacity building**, it is crucial to note the need to develop effective training programs, for example applying peer learning theories, for engaging with the youth, our future leaders, policy and decision makers a process that has already taken shape at IIASA through the CDAT program but also with EQU/POPJUS in the makingAchange project and its African pendant.

In terms of **funding**, since the share of external funding has increased, it is imperative to highlight that the institute will strive to increase NMO funding, whether through new or revived membership of historical members or by increasing the funding provided by existing members. This will be crucial to reinforce research independence and promote innovative ideas. Increasing the number of NMOs would also be beneficial given their role in increasing the impact of country level research and facilitating IIASA staff engagement with policy and

other non-academic stakeholders at different stages of the research. Also, a further expansion of regional memberships (possibly in the Latin American and Asian context) could bring further benefits in this regard.

Vision for the Strategic Initiatives Program at IIASA

The Strategic Initiatives (SI) Program at IIASA is currently undergoing a thorough self-assessment, with valuable input from IIASA SI principal investigators and National and Regional Member Organizations. This evaluation is crucial to understand its future direction, with the goal to focuss more on the needs of the National/Regional Member Organizations (NMOs/RMO), while maintaining support for young researchers and fostering cross-program **collaboration.**

Dual Track Approach

Track 1: Continuation and Enhancement

- Current Terms of Reference: Maintain the existing framework, but focus on only three objectives:
  - Cross-collaboration/Inter-disciplinary research within IIASA's Programs.
  - Innovation through opportunities for Young Researchers: Emphasize the importance of fostering innovation by nurturing early-career scientists, providing them with opportunities to engage in proposal writing and interdisciplinary projects.
  - Novel Ideas and Innovative projects which draw on IIAASA's strengths.

Track 2: NMO-Centric Co-Design Process

- Multi-lateral funding for multi-lateral projects designed by NMOs
- Focus on NMO/RMO Needs: Establish a new track dedicated to projects that specifically address the needs of NMOs/RMO. This track will be co-designed with NMO/RMOs to ensure their priorities are met.
- Senior Researcher Involvement: Given the specialized nature of NMO-driven projects, initial involvement might lean towards senior researchers. However, a combination of senior and junior researchers can be considered to foster mentorship and knowledge transfer.

Explore the feasibility of alternating or running Track 1 and Track 2 in parallel or on a rotational basis (one year, one track, alternating). Another option might be that track 2 would be carried out by the Communications and External Relations program of IIASA with or without support of the SI program.

Additional considerations

Cross-Collaboration and Regional Centers

Suggestion to establish regional centers combining IIASA expertise with that from different institutions, enhancing localized impact and collaboration.

Engaging NMOs/RMO: Challenges and Opportunities

The engagement with NMOs/RMO is critical, yet complex. The heterogeneity of NMOs/RMO, varying levels of activity and engagement, and differing needs pose challenges. Some members are very active, while others might be happy to be less engaged. A potential

solution is to categorize NMOs/RMO based on their interests and requirements, ensuring tailored engagement strategies that respect their unique contexts. To streamline this process, a formalized mechanism to identify and align NMO needs with IIASA's internal processes is essential. This will help in creating a more structured and effective collaboration framework. Throughout the past years, this mechanism has been NMO/RMO workshops, which can continue or evolve into a more NMO/RMO-led process.

Proposals and Collaboration

Integrating a requirement for joint proposals involving both senior and junior researchers can enhance the mentorship aspect and ensure continuity in research excellence. The proposal writing process can be an activity that is funded and limited within a certain time frame, to allow good ideas to be expanded and proper networks to be included in the project, akin to a preparation phase of proposal writing in various national funding agencies.

Conclusion

The SI program at IIASA stands at a crossroads. By adopting a dual track approach, we can ensure that it continues to provide invaluable opportunities for young researchers while also addressing the specific needs of NMOs. The strategic introduction of a tiered approach and regional centers will position the program to better serve its diverse stakeholders and ensure sustainable development. This balanced strategy will help IIASA navigate the complexities of international collaboration and maintain its position as a leading global research institution.

Capacity Development and Academic Training

Lessons learned and future directions

Some lessons learned

- There is a growing demand in Member (MO) countries and elsewhere, for specific tools and modeling frameworks developed at IIASA, methods of systems thinking and systems analysis. Scaling up the transfer of such know-how is currently constrained by limited internal incentives and bandwidth. Orchestrating and streamlining these efforts could render them more effective and efficient, hence more valuable to MOs.
- Funding for IIASA's capacity development activities cannot be taken for granted, and internal resources need to be complemented with external sources. As CDAT activities are to be expanded, the CDAT unit needs to become more entrepreneurial and engaged in raising external funding.
- There is already a substantial number of current IIASA staff who are engaged in teaching and training activities. As activities are to be scaled up, we will need to increasingly involve and rely on trainers and teachers from alumni and MO communities.
- IIASA's unique selling point as an international science hub offers unique and underdeveloped opportunities for offering trainings in science diplomacy and science-to-policy.

Vision/Future directions – Time horizon 2030ish

Our stated vision is a world in which decisions are based on rational analysis and insight, where IIASA trains a growing number of scientists, researchers, and decision makers. Our mission is to develop capacity in systems analysis by educating young and experienced researchers, as well as current and future decision makers in systems thinking, systems analysis as well as specific tools and methods that IIASA has significant expertise in.

Capacity development has the potential to become an integral part of the **value proposition** of IIASA towards its Member Organizations. Our goal is to develop and offer more opportunities (‘**increased throughput’**) to learn about **systems perspectives and evidence-based decision support** at all levels of experience, ranging from school children, through undergraduates to PhD students and postdocs, all the way up to decision makers in policy and business. Thereby, we are increasing **IIASA's network** and rely on input from that network. At the same time our goal is to keep a **high-quality standard**.

The above opportunities could include:

Research clusters of excellence. Modeled on the YSSP, but targeting not only PhD candidates. Creating cohorts of high potential and future leaders at the doctoral or

postdoctoral level, ideally supported by multi-lateral collaboration between IIASA and top universities in MO countries, and potentially linked thematically. Members of these cohorts would be carrying out their research at one or two places of their choice (incl. IIASA) and regularly convene to explore synergies between their projects and potential collaborations. ('business class' PhD and postdoc programs)

Cohorts could also be formed from creative practitioners and administrators who need theoretical input and backing. IIASA could act as an incubator, where the cohorts can freely explore novel approaches to systems analysis and change management, transcending academic or professional constraints. A first step towards creating such cohorts is to expand the postdoc program to 25 scholars per year by 2025, and to sharpen the existing PhD visitors scheme. In 2025, we also host 30 school children carefully selected from local schools for a year-long program and start towards a teacher training program. Programs for senior levels to follow.

IIASA Training campus. Such a structure could offer, *inter alia*: courses in systems analytical methods (building on the 2024 summer school on systems modeling); training workshops on specific modeling tools (building on the trainings already done on MESSAGE/GAINS/CWatM); thematic workshops that cut across the global and IIASA agendas (e.g. Systems perspectives on the SDGs; Systems perspectives on biodiversity, etc); training academies on specific topics in science diplomacy and negotiations, for example in cooperation with the Raiffa Center that is currently being discussed. The target groups would range from early career researchers, through technical experts in national agencies, all the way to mayors. A realistic goal is to offer 10 such in-house courses per year by 2030 (1-2 weeks each). Topics could be determined strategically but also through open calls. The Training campus would be housed in the Palais Kaunitz-Wittgenstein in Laxenburg, a few minutes' walk from the IIASA premises.

IIASA regional training camps. Building on the successes with the Training Campus in Laxenburg, IIASA could roll out, together with the NMOs/RMOs, regional training programs, bring the experience from international networks to regional and local decision makers. There would be some involvement from IIASA's researchers in the training program, but a large part would be delivered by experts from the respective region. The goal is to deliver 2-3 of such training camps per year by 2030.

Virtual trainings. An increasing number of training activities can be delivered in a virtual or hybrid format. In addition, novel knowledge platform concepts involving generative AI will be explored to remain relevant also in 2030.

Visiting scholar programs ("Global Scholars Program"). IIASA could attract scholars at senior career stages to spend time at IIASA (weeks to months to one academic year). CDAT would want to involve these at low intensity also in training activities for our own researchers, the above research clusters and the Training campus.

Dual affiliations ('IIASA Professorships"). The capacity and quality of IIASA's teaching activities would be increased by working with universities (local and in NMO/RMO countries) towards dual affiliations.

The future of the YSSP. The YSSP is a successful program with a long history that we will maintain in its current format and size and only carefully adjust from year to year as is

deemed necessary. Calls for additional opportunities for PhD students will be answered by offering alternative formats (see above).

Activation of the IIASA network. In all the above we will engage IIASA alumni and IIASA's international networks. Our goal is that most courses at IIASA and all regional training camps involve alumni or regional experts. In addition, by 2030 10% of the YSSPs would involve a guest mentor.

Intellectual onboarding of IIASA researchers and long-term visitors. This could become more formalized, making sure that new IIASA researchers have spent a minimum amount of intellectual capacity on concepts and methods of systems analysis that go beyond their own expertise. This could be achieved through a structured on-boarding curriculum.

Funding. Some core CDAT activities will continue to be funded internally. IIASA will be able to leverage many scholarships that our visitors will win to come to IIASA and to pay for registration fees (or overheads the institute charges). IIASA, through CDAT, will be a fully funded partner in a number of regional and global networks and research consortia that would like to access IIASA know-how and training opportunities.

Advisory board. CDAT activities could benefit from an international advisory board, whose expertise would cover, inter alia: methods of systems analysis; international graduate programs; international capacity development programs; science to policy; science diplomacy; opportunities for funding; quality assurance in teaching.