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Commentary

Combatting Relative Sea-Level Rise at a Global Scale: Presenting the International Panel on Land Subsidence (IPLS)

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Land subsidence is increasingly recognized as a critical factor exacerbating relative sea-level rise (SLR), particularly affecting coastal cities and delta regions worldwide. Despite its significance, subsidence is often underrepresented in global SLR assessments. This manuscript introduces the formation of the International Panel on Land Subsidence (IPLS), which aims to unify scientific communities and global research efforts, improve monitoring, modeling, projections and mitigation strategies, and integrate subsidence with global SLR projections. We outline a roadmap for the IPLS to become a pivotal resource in global environmental policy, similar in scope to the IPCC. By fostering intergovernmental collaboration and standardizing responses, IPLS seeks to place land subsidence prominently on international agendas, provide mitigation strategies to reduce coastal land subsidence, and thereby relative SLR, and enhance the resilience of vulnerable coastal populations.

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Introduction - Subsidence - from local phenomena to global challenge

Land subsidence is rapidly becoming an environmental pandemic that could impact the lives of almost a fifth of the global population (Herrera-Garcia et al., 2021). This increase is associated with steep and unregulated population growth in subsidence-prone landscapes such as river deltas and coastal plains (Nicholls et al. 2021) and increased human activities, like subsurface resource extraction and drainage, triggering and accelerating human-induced subsidence through various processes (Candela & Koster, 2022). Especially populations in developing countries have higher chances of becoming exposed to land subsidence, as water governance and institutional effectiveness are less developed (Dinar et al., 2021). In addition, within societies, subsidence is disproportionately impacting the poor, while benefits from subsidence-triggering activities like water and hydrocarbon extractions flow elsewhere.

Coastal subsidence at the world's coastlines can considerably accelerate local relative Sea-Level Rise (SLR) (Shirzaei et al., 2021; Törnqvist & Blum., 2024). Today, many coastal environments, such as river deltas, wetlands, and coastal cities, experience accelerated land subsidence rates due to anthropogenic factors. The coastal population worldwide (>500M people) living in low-lying and subsiding coastal regions experiences, on

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average, four times higher relative SLR than the global mean average SLR because of subsidence (Nicholls et al., 2021). Although land subsidence is the dominant force driving relative SLR worldwide, its effect is often overlooked and/or not fully integrated into global and local sea-level rise projections. In the most recent IPCC's SLR impact assessment (IPCC, 2022), subsidence is considered a 'local phenomenon' and only received attention in a few case studies. Alternatively, land subsidence is improperly addressed by climatologists or oceanographers (Hinkel et al., 2013), with over-simplification (e.g., temporal and spatial averaging) that makes projections largely questionable. As the land component is often not or insufficiently included, the SLR impact assessments underlying coastal adaptation plans for many governments around the world over- or underestimate future relative SLR rates and consequent flood risks.

Meanwhile, the relatively small but dedicated scientific community worldwide is working to improve monitoring, understand its governing mechanisms, advance numerical models and develop reliable projections of subsidence (see Shirzaei et al., 2021 for an overview). And advances are being made toward standardizing response strategies to curtail subsidence (Erkens & Stouthamer, 2020) and reduce economic damages (Wade et al., 2018). We have the scientific knowledge and tools to govern and mitigate subsidence effectively, but apart from a few exceptions, the subject is still low or often completely absent on political agendas. And this is not likely to change as long as land subsidence is viewed as a local phenomenon and treated on a case-by-case basis rather than the global environmental pandemic it is becoming.

Hence, it is more important than ever for the global scientific community from all biophysical and socio-economical domains, studying the drivers and processes, impacts, and coping strategies of land subsidence, to unite similarly to the IPCC that has come into existence in the 80's, to combat the growing global challenge of land subsidence and to add the crucial addition to global relative SLR projections from the *land* perspective. And this is paramount as the next decades will be crucial to ensure the best possible outcome position for densely populated coastal areas around the world, specifically in developing regions not largely affected by land subsidence yet, and is dictated by our effectiveness in reducing and avoiding further unnecessarily human-induced subsidence.

Uniting the global subsidence research communities within the International Panel of Land Subsidence (IPLS)

We present the International Panel on Land Subsidence (IPLS)(http://www.IPLSubsidence.org). An initiative launched in a similar spirit to the IPCC. The IPLS is envisioned as a 'by all, for all' community that aims to grow in the coming years to become a global focal point of scientific knowledge made available in an accessible matter, to place subsidence higher on the international agenda, properly integrate coastal land subsidence into SLR projections of the IPCC and communicate effective strategies for mitigation and adaptation of subsidence to governments.

We propose the following roadmap (Fig. 1) to grow the IPLS initiative by developing a global community of forward-looking scientists. IPLS aims to communicate ongoing developments, webinar series, organize knowledge exchange and brainstorming events, training workshops and write joint scientific papers on crucial issues. IPLS aims to produce thematic assessment reports on Land Subsidence and integrate 21st-century projections of (coastal) land subsidence and land elevation change into IPCC's SLR projections within the 7th Assessment Report cycle, to inform governments, scientific communities, and the public worldwide.

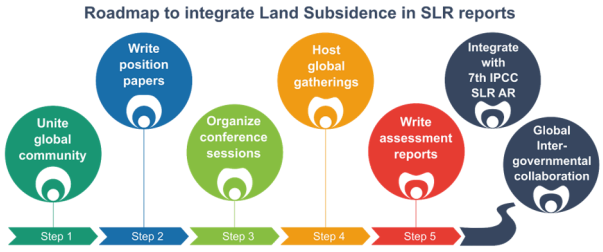

Figure 1. Roadmap to grow the International Panel on Land Subsidence (IPLS), methodologically integrate coastal land subsidence into IPCC SLR reports and foster global intergovernmental collaboration on mitigating land subsidence.

IPLS aims to collaborate with other groups and initiatives already established and focused on land subsidence from different points of view. For example, the UNESCO International Initiative on Land Subsidence (https://www.landsubsidence-unesco.org/),

whose focus is broader than coastal areas and on human-induced subsidence, and the "Science, Economics and Policy of Global GW Over-Extraction and Land Subsidence" group (https://waterdialogue.ucr.edu/land-subsidence) that gives attention on identifying the types of damages caused by land subsidence and quantifying them both in terms of the various physical impacts and their economic values.

We foresee integration with IPCC reports to improve projections of local relative SLR and design inclusive mitigation strategies for both greenhouse gas emissions and land subsidence. By becoming the focal point for global intergovernmental collaboration, the IPLS can provide coastal communities and governments with the much-needed action to avoid unnecessary and otherwise avoidable coastal land subsidence. And this is paramount as unimpeded coastal land subsidence otherwise strongly weakens the resilience of coastal communities to withstand future climate change-induced sea-level rise.

IPLS, By All, For All

The IPLS welcomes all experts from disciplines related to subsidence, from the natural sciences to the socio-economics and humanities, to join the IPLS initiative. The IPLS aims to steadily grow and develop dynamically by bringing together different disciplines and existing initiatives while developing own new ideas and initiatives. The IPLS thrives on fostering a strong and representative global scientific community that is forward-looking and keen to change the world's future in the coming decades. Therefore, early-career scientists and scientists from usually underrepresented countries are especially encouraged to join. To stay up-to-date with the latest developments interested parties can register to the IPLS mailing list through the website, which will be used to send out regular updates, invitations to webinars, conference sessions and other events, and share opportunities such as writing position paper and research reports.

Planned community actions and outlook following the IPLS roadmap

- **Build global community**. The first step is to grow a global community of researchers and scientists working on vertical land motion, land subsidence, and relative SLR. Communications will take place via the IPLS newsletter and social media channels. The IPLS community will receive a regular IPLS newsletter presenting IPLS progress, selected advances in land subsidence research, and opportunities to contribute to the initiative. In addition, we envision (online) brainstorming sessions to create ideas and common ground for the future development of the IPLS. And an online seminar series of inspiring talks on subsidence. On top, the IPLS initiative is well-suited to be included in existing and future research efforts and projects on land subsidence by research groups worldwide to provide and strengthen research valorization and dissemination.
- **Write position papers.** To increase the international visibility of the subject and highlight the need for our community to pull together, we plan to instigate the writing of various position papers on larger IPLS-related themes by rotating groups of authors. This collection of papers will provide the scientific basis for further building the initiative.
- **Organize conference sessions.** The IPLS will organise dedicated scientific sessions as part of larger conferences (e.g. EGU/AGU/AOGS) to provide a continuous session series on land subsidence and relative SLR research to enable the growth and exchange of scientific advancements and stimulate peer-discussion, while building visibility and grow the initiative.
- **Host regional and global gatherings**. Following a growth in community and momentum the IPLS eventually aims to host gatherings at regional and/or global level. To facilitate effective networking, collaboration and discussion and planning of following necessary steps and setting a common research agenda.
- **Write thematic assessment reports on land subsidence and relative sea-level rise.** The IPLS will produce thematic assessment reports that cover relevant aspects and topics on land subsidence and relative SLR integration.
- **Global coastal land elevation change projections to enable integration with IPCC's SLR scenarios (IPCC).** The IPLS plans a concrete data product of 21st-century projections of (coastal) land elevation change. The foreseen projections of 21th-century land elevation change will add value to IPCC's global SLR projections and enable the creation of consistent local, regional and global *relative* SLR projections. The central aim is to elevate the projections of relative SLR from the current ad hoc (only when data is available) and often oversimplified (e.g. using single constant values for large areas over longer time periods), to robust, transparent, and consistent projections of relative SLR at the regional and global

level. The envisioned framework to create global coastal elevation change projections will be created in a manner to allow continued future improvements by the IPLS community across spatial scales (global, regional, local), timescales, and subsidence forcings. The relative SLR projection will be freely available and usable to governments, scientists and the general public worldwide.

- **Global intergovernmental collaboration on land subsidence control and mitigation.** In the long run, through thorough scientific work and clear and consistent communication at regional and global level, the IPLS aspires to increase global intergovernmental dialogs and knowledge exchange on land subsidence to increase awareness and strengthen intergovernmental collaboration to manage and mitigate land subsidence effectively. We believe this is crucial and timely as failure to address and reduce current and future coastal land subsidence will drastically worsen the position of coastal population and assets worldwide to face the inevitable future global SLR following climate change.

Notes

- Previous versions: v1.0 December 2022, v1.1 September 2023, v1.2 April 2024
- Visit the IPLS webpage (www.IPLSubsidence.org) and subscribe to mailing list

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Declarations

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