

Regional Science Dialogues for Peace and Sustainable Development

Terceira Island, Azores, Portugal & Virtual Event

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Terceira-S49-S1 Networks in Resilience and Vulnerability

Looking for vulnerabilities in health security: the need to integrate regional-level and world-scale connectivity networks of disease transmission

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Why are we here and where are we (beyond Terceira)

Our participation to the meeting: special thanks to Prof. Aura Reggiani




Congress title, ...
Regional Science Dialogues for Peace and Sustainable Development

... session title...
Networks in Resilience and Vulnerability

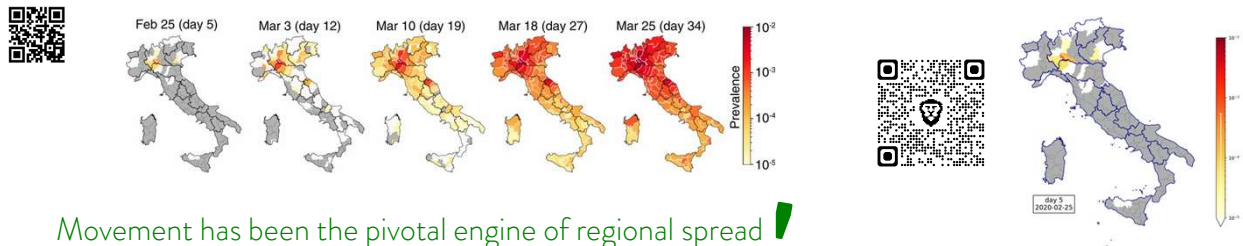
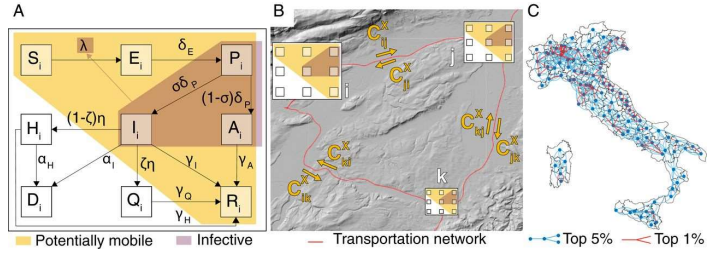
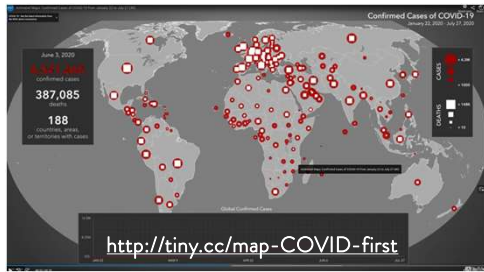
... and our recent times



we are here

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... and then COVID-19 came, with an amazing global...



Movement has been the pivotal engine of regional spread !

Gatto, Bertuzzo, Mari, Miccoli, Carraro, Casagrandi and Rinaldo (2020), PNAS 117: 10484

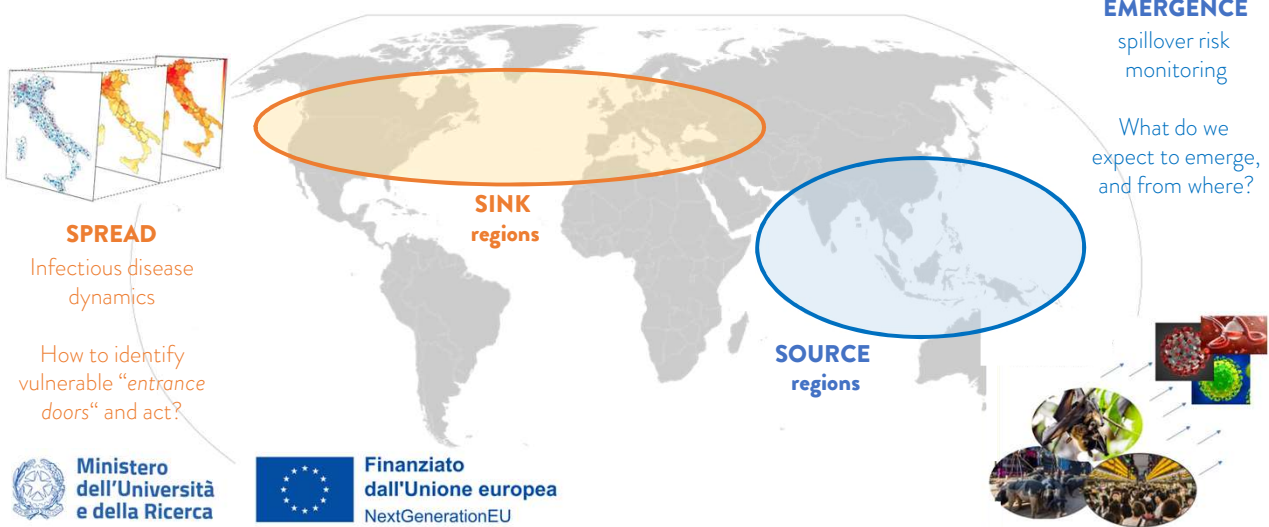
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The project PREPARED

One Health PREPAREDness: an integrated framework to manage the risk of zoonotic disease emergence



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What do we expect to emerge? The WHO Blueprint List

NOTA BENE:
Bats are very important reservoir hosts!

We therefore exemplify the framework for Indonesia

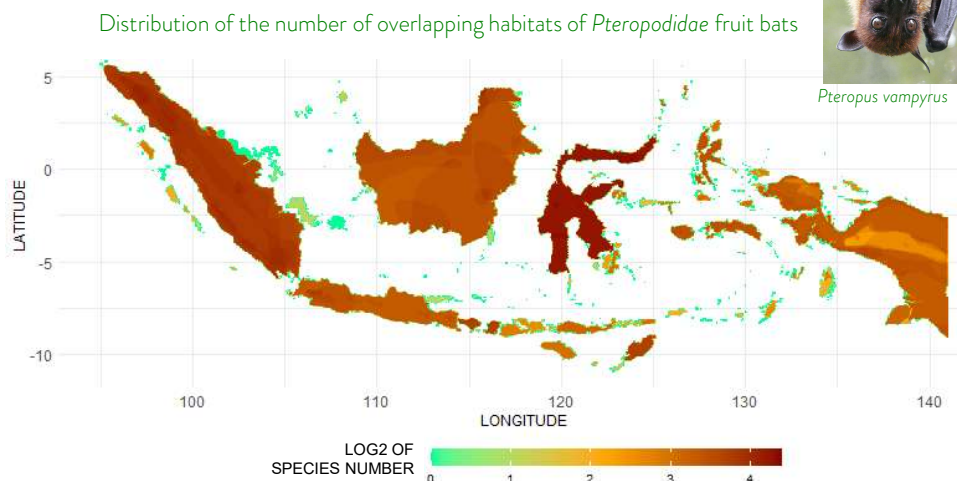
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How can we map the hazard (H)? A simplified (yet reasonable) data-informed way

“ We show that ... the number of human-infecting viruses increases proportionately to the total number of viruses maintained by each reservoir group, which is in turn explained by the number of animal species within each group ”

Mollentze and Streicker (2020) PNAS 117:9423



SOURCE: IUCN RedList

Note: the number of species S is mapped in log₂ scale (0 < S < 20)

Getting in contact with the pathogens: where are the people? And where do they move?

We participated to the **NetMob 2024 Data Challenge**



Researchers are provided with **aggregated mobility datasets** for 4 counties in the Global South (Columbia, India, **Indonesia** and Mexico)

The **spatial resolution** is geohash 5 (with average grid cell size of 4.9 x 4.9 kms) and geohash 3 (ca. 156 x 156 kms)

The **temporal resolution** is daily and annual

Population Density Data:
daily presence of mobile users (number of devices detected at specific locations on a daily basis)

	geohash_5	users	local_date
1	qqguh	2021	20191014
2	qqw7z	1726	20191014
3	qqguw	8028	20191014
4	qqw5d	40	20191014
5	qquhr	462	20191014
6	qquh6	3223	20191013
7	qw6wy	51	20191014
8	qw850	483	20191012
9	qqz8q	42	20191014
10	qxgms	18	20191014

	start_geohash5	end_geohash5	trip_count	local_date
1	qqy81	qqy81	71	20190125
2	qqsyq	qqsyn	13	20190125
3	qqu58	qqu58	71	20190125
4	w0wht	w0wht	54	20190125
5	qqwxc	qqwxc	46	20190125
6	qw84g	qw84f	16	20190125
7	qw8ce	qw8c7	15	20190125
8	qq446	qq446	13	20190125
9	qqggv	qqgvj	10	20190125
10	w85df	w85df	13	20190125

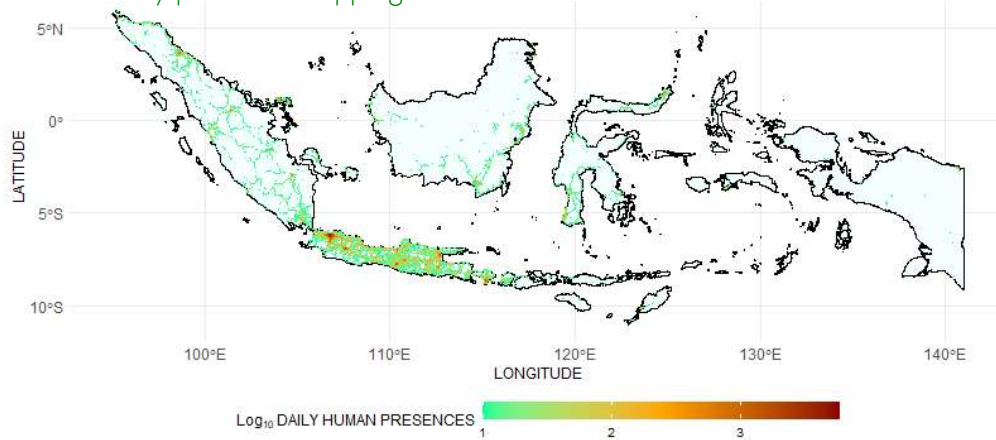
Origin-Destination Matrix Data:
flow of devices between two consecutive stops within a single day

The two datasets made available



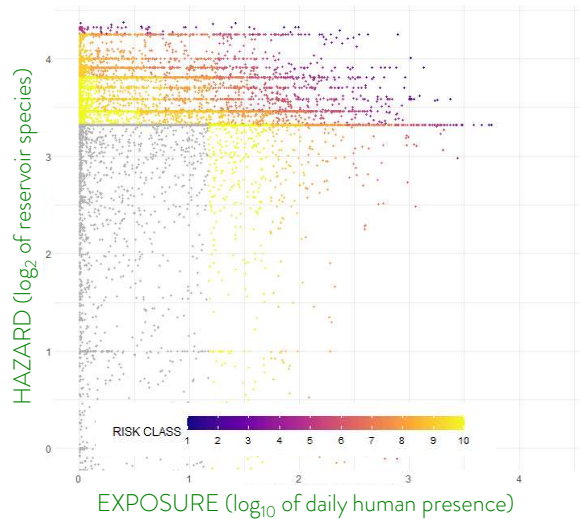
The human component of the risk: the exposure (E) map

Daily presence mapping of mobile users in the first dataset



Note: the number of people is mapped in log₁₀ scale (i.e. orders of magnitude)

How to combine the hazard H and the exposure E to evaluate the risk?

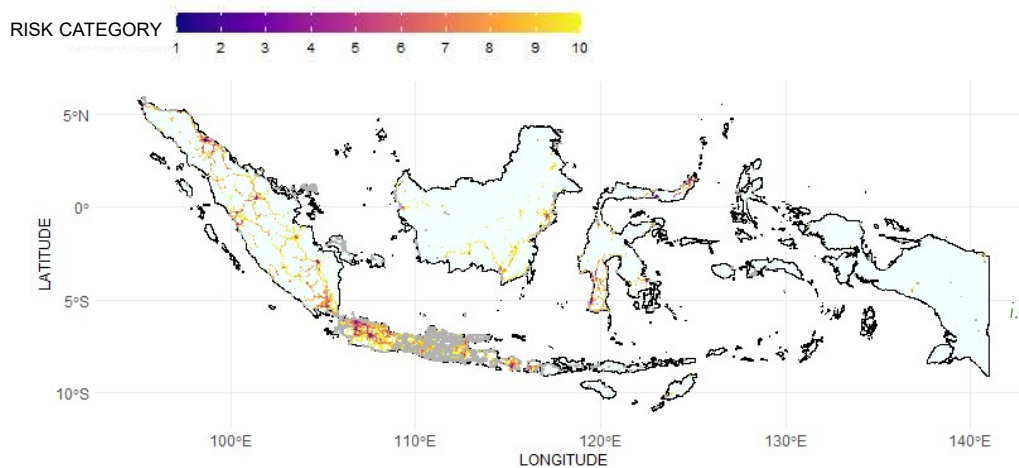


Note the log-log scale

Identify the Pareto-frontiers
(representing different levels of risk)

Group the risk levels into risk categories
(using an octaval approach, *sensu* Preston)

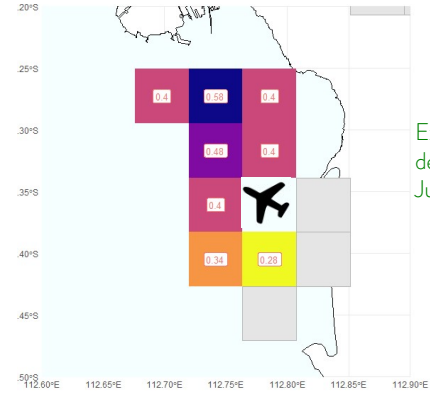
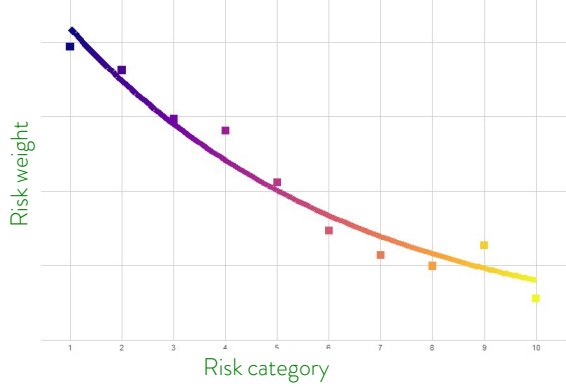
Categorical mapping of transmission risk from bats in Indonesia



Can we use this info
to estimate
transmission risk at
LDD nodes,
i.e. key to regional/global
diseases spread
(e.g at airports)?

Approximating the potential infection risk in each cell

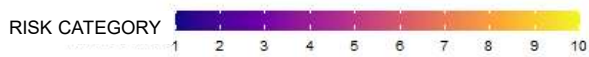
Taking a proper median radius of points in the (E,) space for Pareto categories as a plausible risk weight to scale human presence in each cell, we obtain the following behavior...



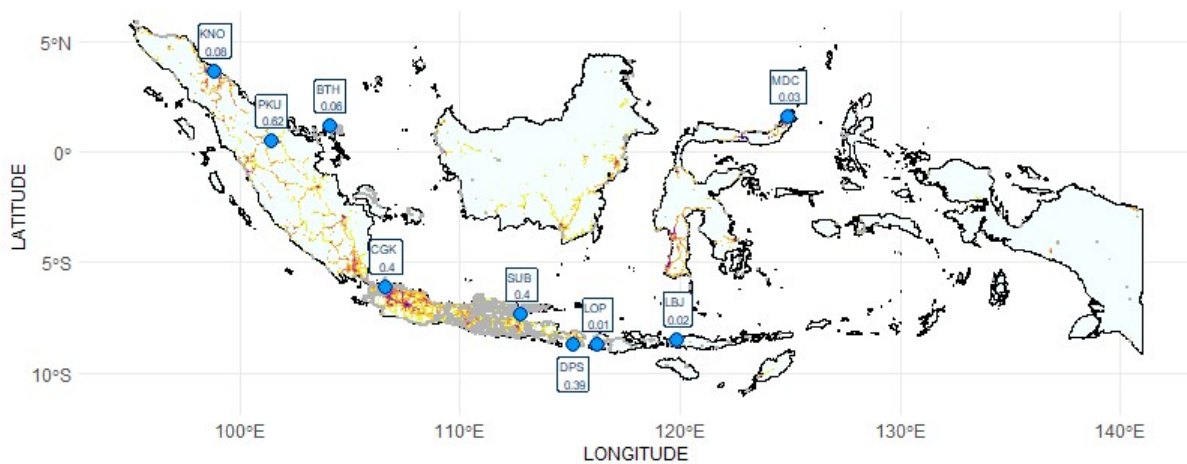
Exemplificative details around Juanda airport

... and so we can weight by potential transmission risk the Origin-Destination matrix for people reaching e.g. airports

Ranking LDD nodes at source (airports here) by potential transmission risk



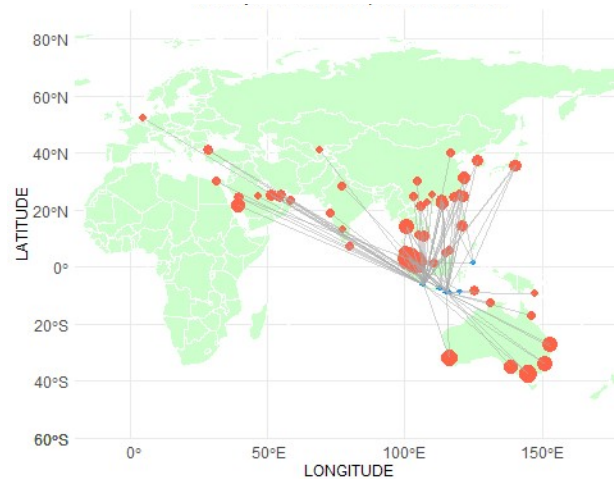
Our exemplificative map



From national to regional... to global scale

Knowing the flows of international passengers, we can “easily” propagate the potential transmission risk from source regions to sink regions

Risk propagation to airports with direct flights to Indonesia



Conclusions

By combining the **hazard of pathogen emergence** with the **exposure of moving people** it is possible to build methodologies to estimate risk of spread

The case presented here for **Indonesia** is but an example on how to proceed, studied to elaborate a **preparedness framework** for identifying vulnerabilities in disease spread

The **availability of better data** and/or models for mapping hazard and exposure, as well as of alternative procedures to estimate the propagation risk may **improve the results**