Applying Bayesian network analysis to explore Okinawa coastal fishers' perceptions of climate change impacts on well-being

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Okinawa Institute of Science and Technology (OIST) Complexity Science and Evolution Unit

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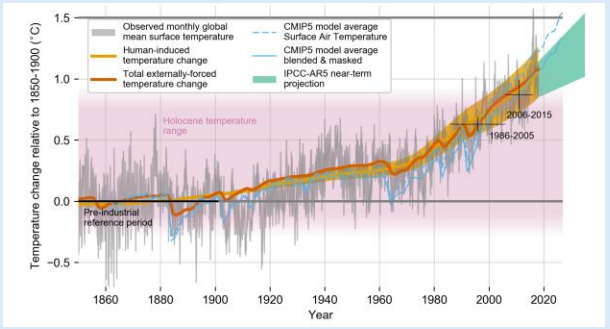
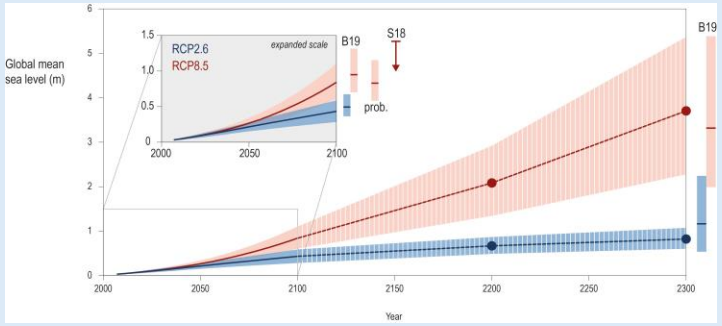
Background – Perceptions as a Bridge to Action and Well-being –

- Climate change threatens people's livelihoods and reduces ecosystem services, especially in coastal areas.
- Meteorological data shows clear changes in coastal environments and climate patterns. (e.g., temperature, sea level rise, and eutrophication)





Figures. The changes in global mean surface temperature (left) and the projected sea level rise (right), referenced by IPCC

- People perceive these changes subjectively, based on their own experiences.
- **Understanding people's perceptions of climate change and future risks is crucial**
  - to promote sustainable actions
  - to improve well-being

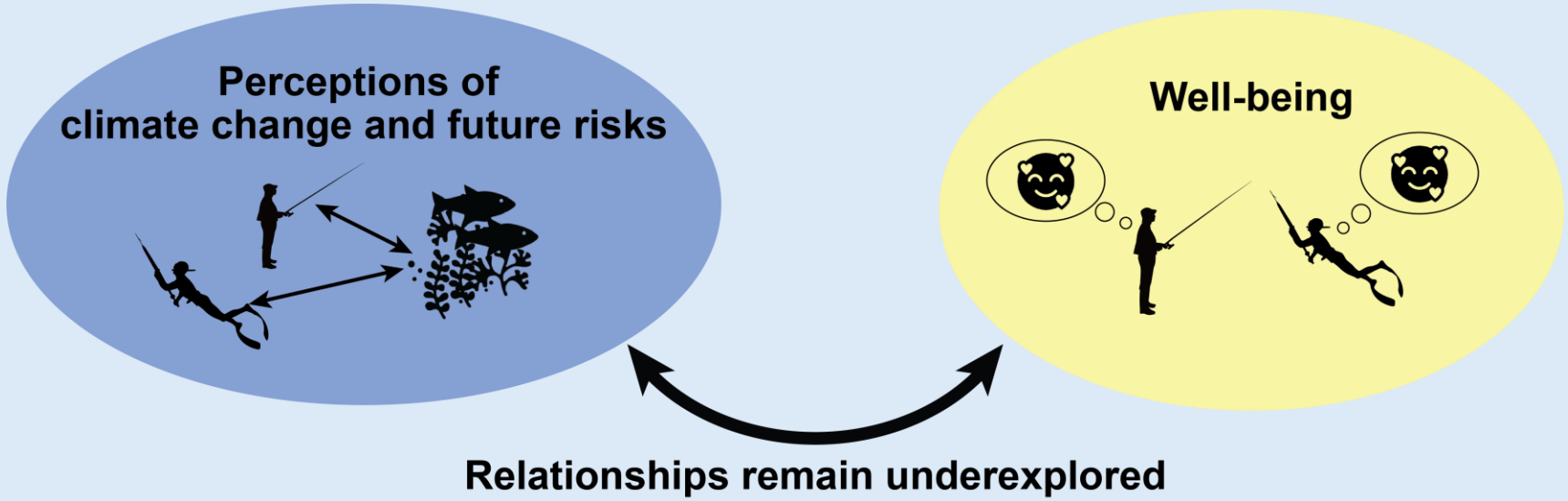
The research gap and study aim

- This study focuses on fishers' perceptions of climate change, future risks, and well-being, as they are local knowledge holders who engage with the environment in their daily lives.
- Many studies have explored them in isolation.
- However, the relationships between them remain underexplored.

The aim of this study:

1. To identify factors shaping fishers' perceptions of climate change, future risks, and well-being

2. To explore the relationships between these perceptions and fishers' well-being

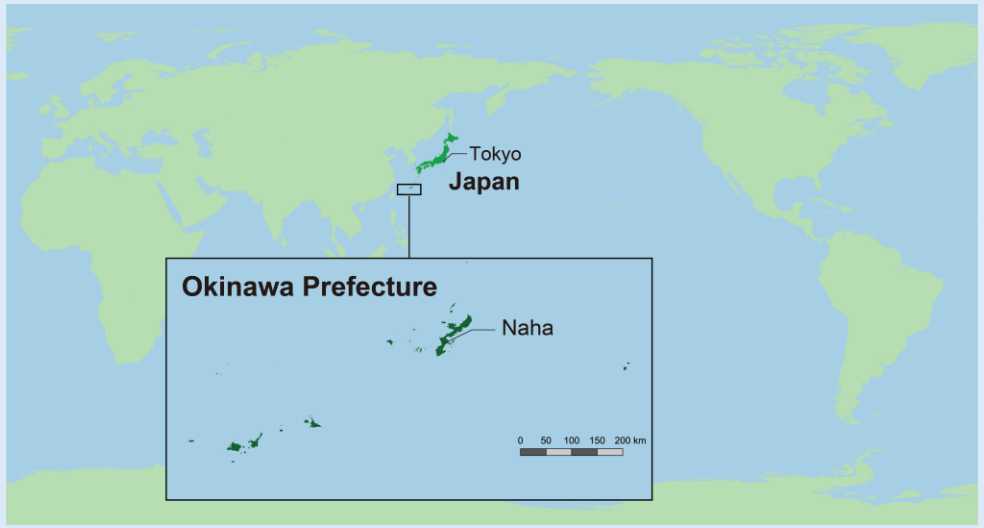


The scopes of this study

1. Study site: **Okinawa, Japan**

- Subtropical islands in southwest Japan with rich biodiversity
- Vulnerable to climate change impacts
- Fishers have autonomy in the coastal government

⇨ Fishers' perceptions may have strong impacts on policy design



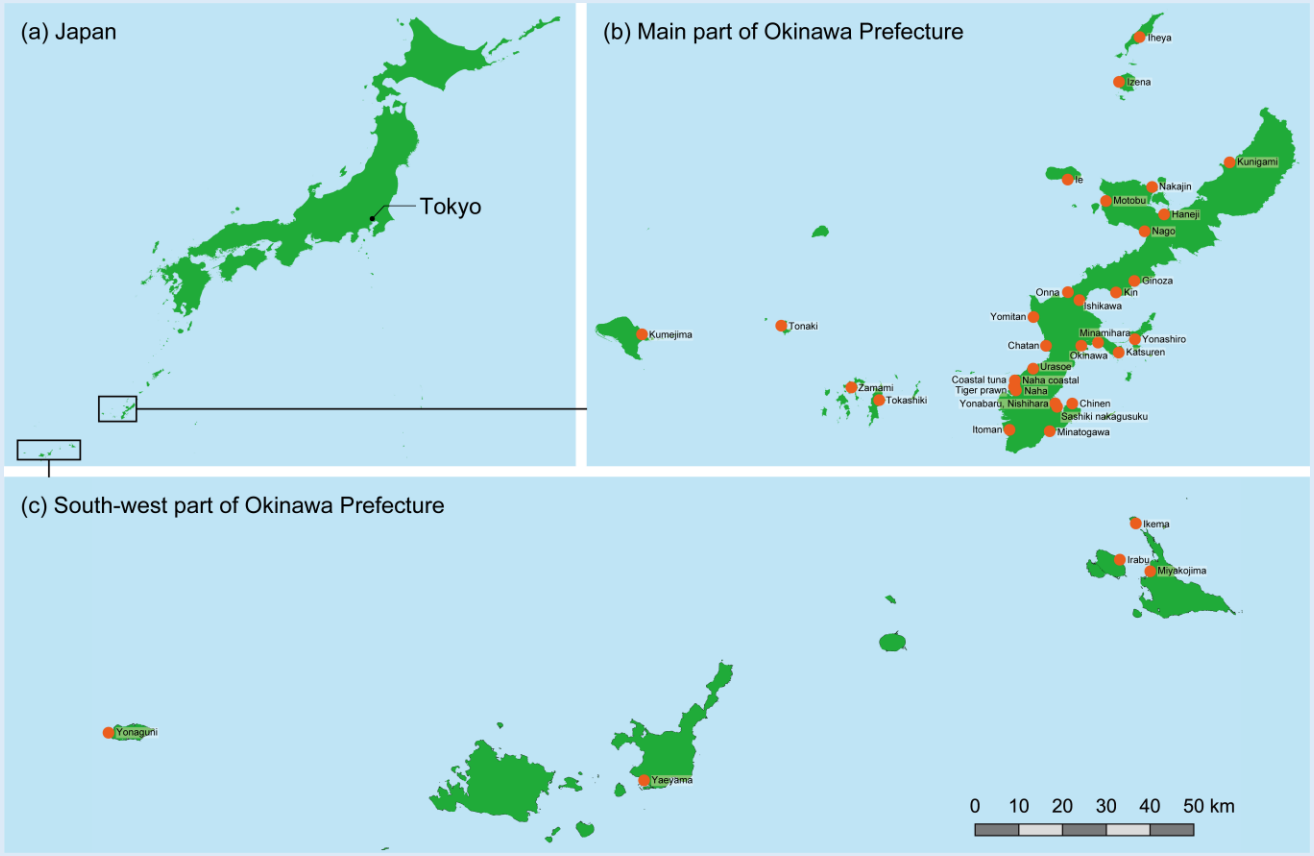
2. Policy orientation and interactions with local stakeholders

- Supported by the Okinawa Federation of Fisheries Cooperative Associations
- Planning to write a research report for the Okinawa Prefectural Government as a policy reference

Data collection

A questionnaire survey was conducted with fishers in Okinawa.

A total of 511 responses were obtained from 33 of 36 fisheries cooperatives.



The survey topics:

1. Perceptions of climate change (binary / 12 items)
2. Anticipated future risks and actions (ordinal / 16 items)
3. Fishers' health conditions (ordinal / 7 items)
4. Relative importance of fisheries-related factors (ordinal / 12 items)
5. Fishers' overall well-being (ordinal / 13 items)
6. Demographics

Data analysis (2 steps)

Step 1: Factor analysis

- **This method identifies factors shaping fishers' perceptions of climate change, future risks, and well-being (Aim 1).**
- Based on survey responses, it identifies "factors" that
  - represent shared underlying concepts among participants
  - summarize patterns across multiple survey items

Step 2: Bayesian Network analysis

- **This method explores the relationships between these perceptions and fishers' well-being (Aim 2).**
- Using probabilistic calculations, it identifies possible relationships and visualizes them as a network map.
- It helps estimate potential cause-and-effect structures under uncertainty.

Step 1: Factor analysis

– Example questions –

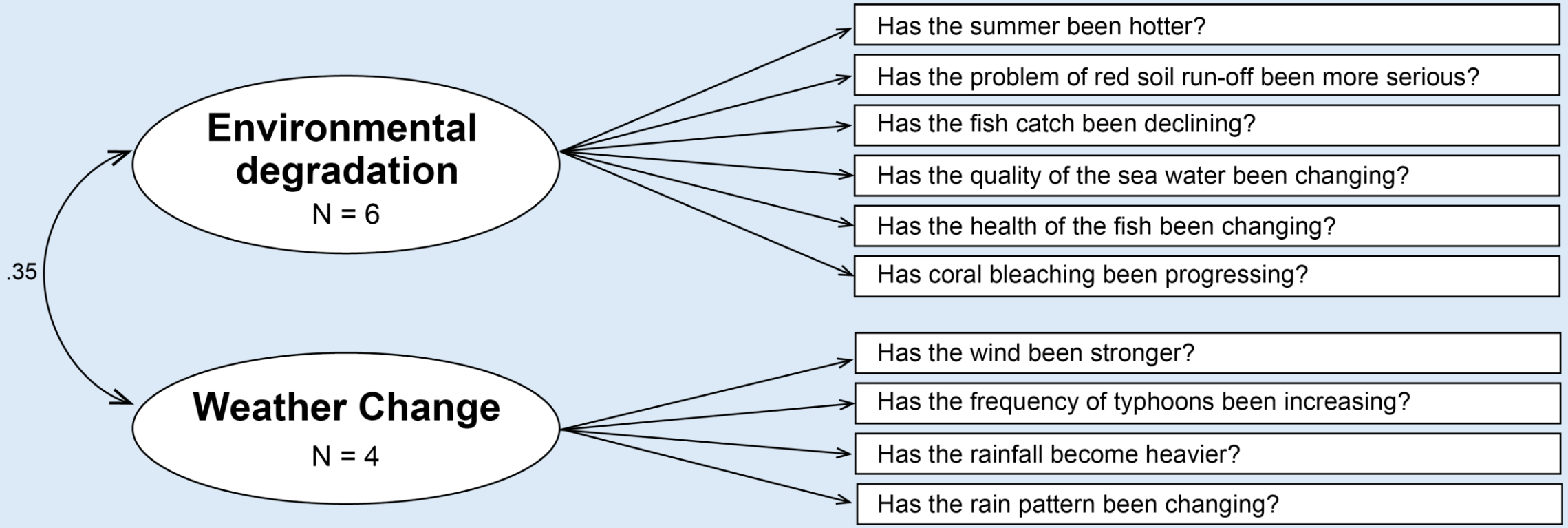
- We asked 12 questions about the perception of climate change.

Compared with 10 years ago…
Has the summer been hotter?
Has the winter been colder?
Has the wind been stronger?
Has the frequency of typhoons been increasing?
Has the rainfall become heavier?
Has the rain pattern been changing?
Have infectious diseases increased?
Has the problem of red soil run-off been more serious?
Has the fish catch been declining?
Has the quality of the sea water been changing?
Has the health of the fish been changing?
Has the coral bleaching been progressing?

Step 1: Factor analysis

– Example –

- Factor analysis identified two factors based on the response patterns.
- We named these factors according to the question items that consist of them.
- This suggests that respondents perceive them as distinct aspects.
- Using these factors helps summarize information and improve interpretation.

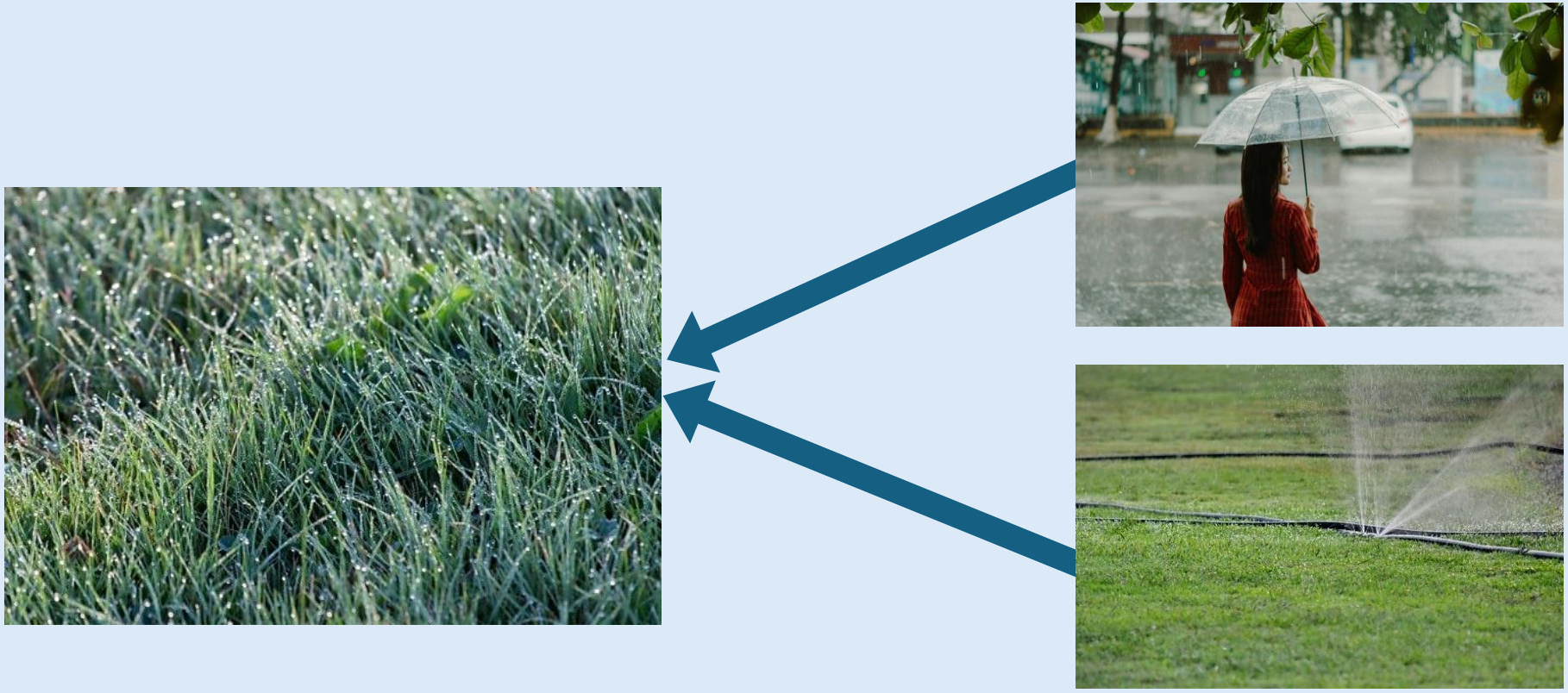


Step 2: Bayesian Network Analysis

– Example –

When you see wet grass, you may wonder what causes this situation (because of rain or sprinkler?)

Bayesian Networks can estimate it through a probabilistic approach!



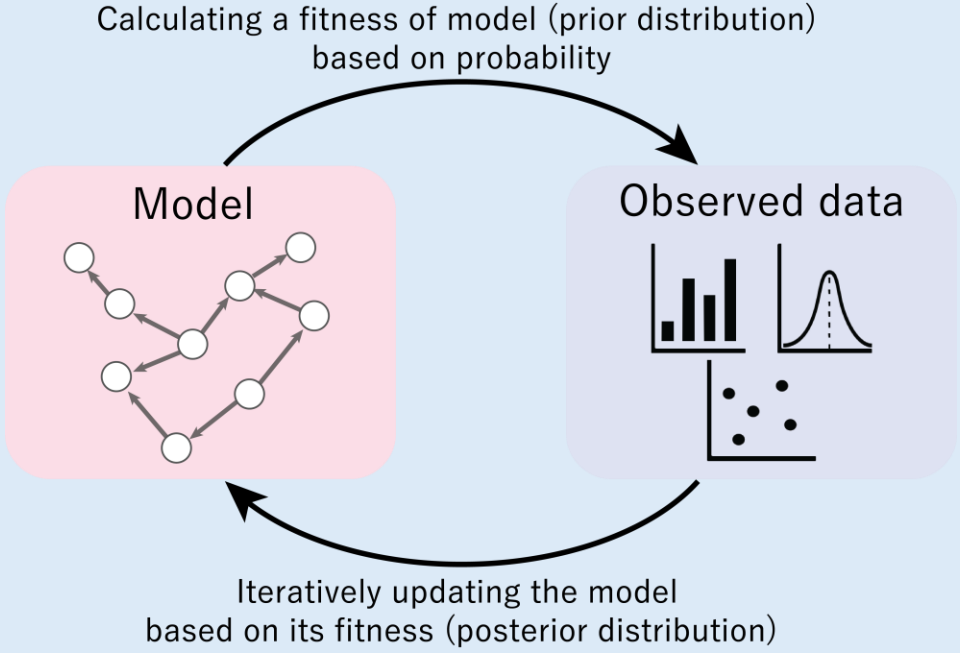
Step 2: Bayesian Network Analysis

- It concisely represents potential cause-and-effect relationships as a network map under uncertainty.
- It combines Bayesian estimation and network analysis:

Bayesian estimation

An approach to estimate the underlying model from observed data using a probabilistic approach

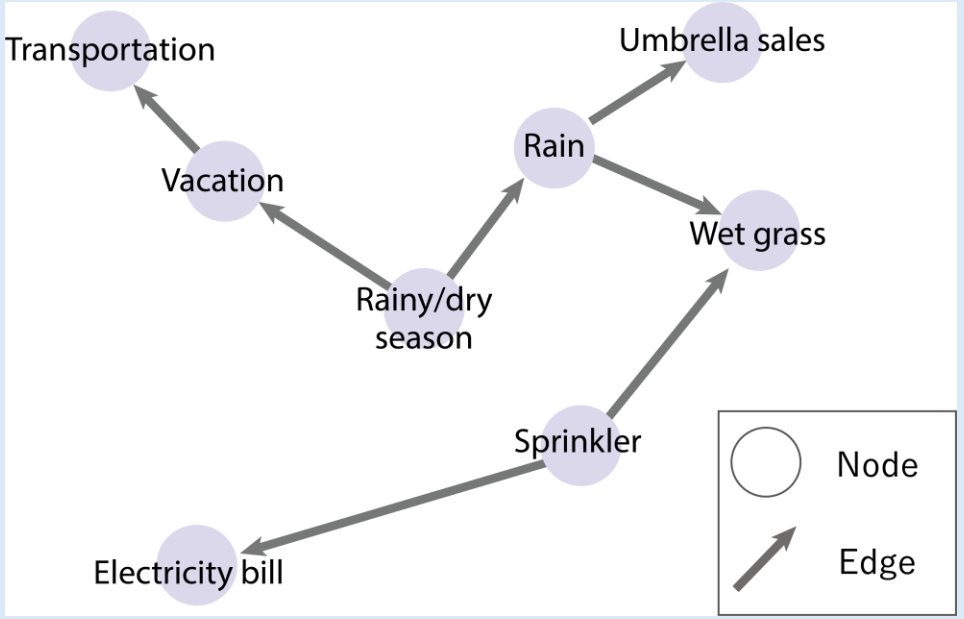
The model is refined iteratively



Network analysis

A method for exploring the interactions between various components in a complex system

Nodes show components, while edges represent relationships



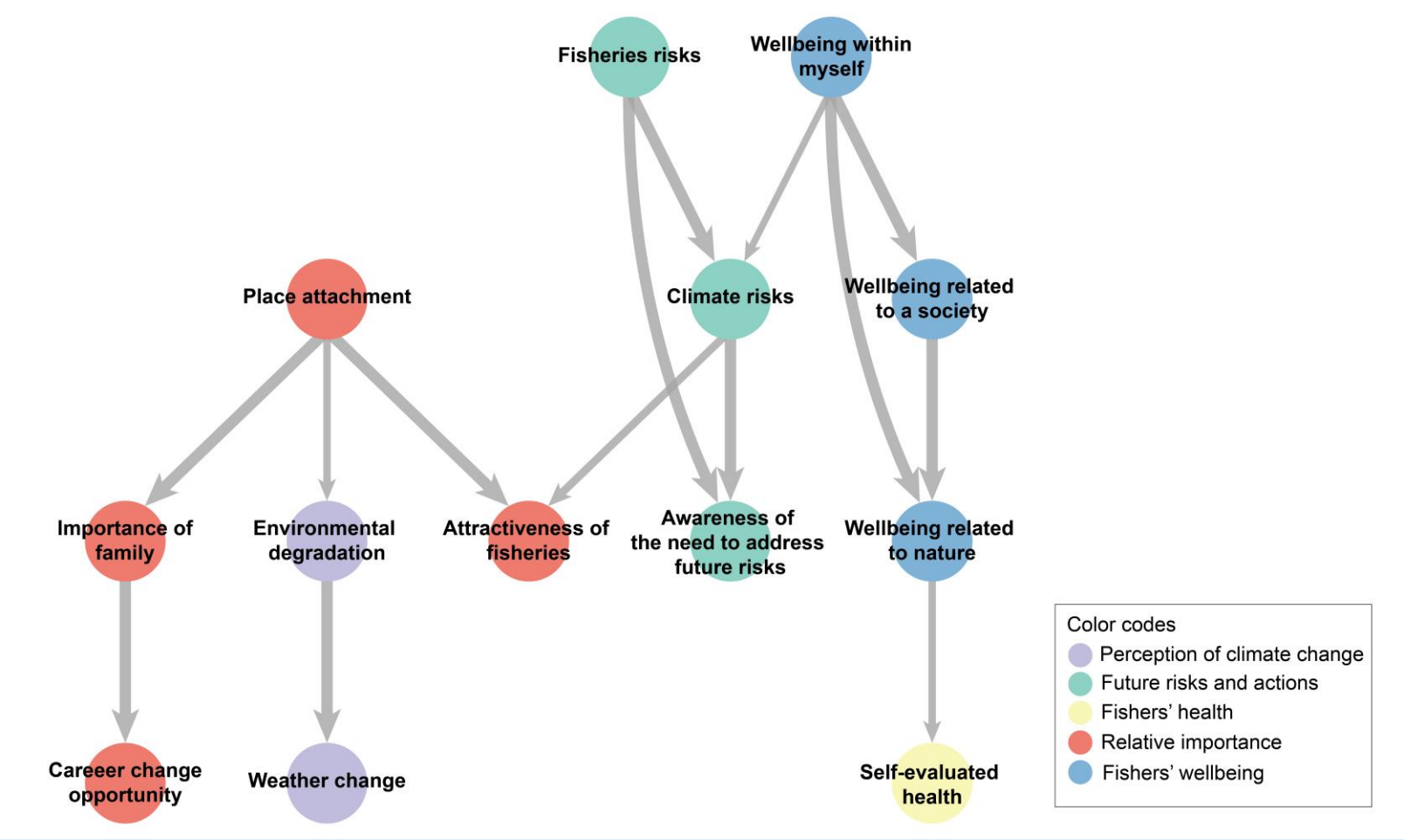
Results – factors shaping fishers' perceptions and well-being –

13 factors were identified out of 60 question items

Topics	Factors	Question items	Explanation (%)
Perceptions of climate change	1. Environmental degradation	6	24.2
	2. Weather pattern change	4	21.9
Anticipated future risks and actions	3. Climate risks	5	18.7
	4. Fisheries risks	4	14.1
	5. Awareness of the need to address future risks	6	28.6
Fishers' health conditions	6. Self-evaluated health	4	23.7
Relative importance of fisheries-related factors	7. Attractiveness of fisheries	6	34.6
	8. Place attachment	2	14.4
	9. Importance of family	2	13.2
	10. Career change opportunity	2	15.0
Fishers' overall well-being	11. Well-being within myself	3	12.5
	12. Well-being related to society	4	22.5
	13. Well-being related to nature	5	18.1

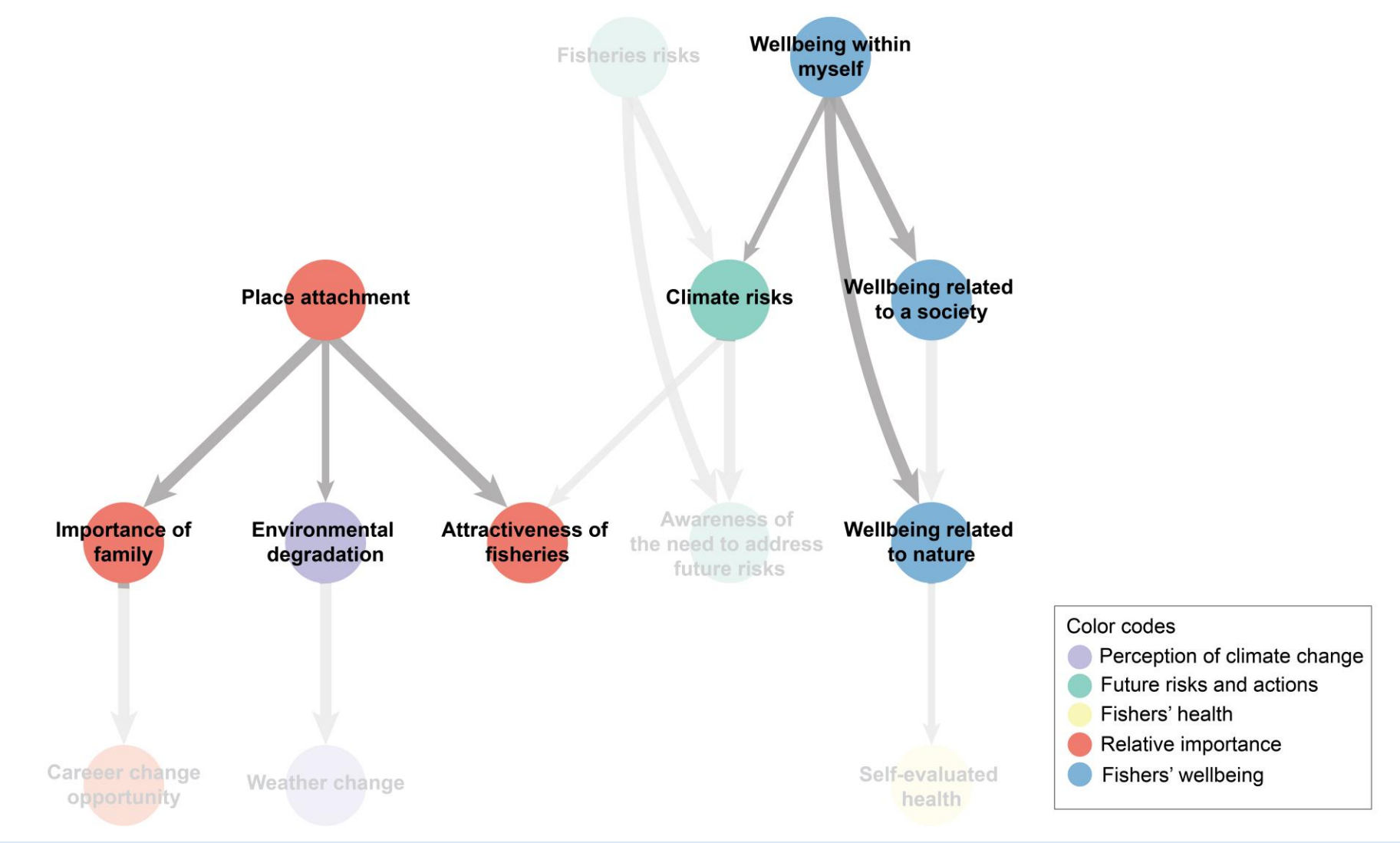
Results –relationships between identified factors–

- Structure learning algorithm based on model selection criteria (AIC and BIC scores):
  Max-Min Parents and Children (MMPC) combined with Tabu search (a typical Hybrid approach)
- The final network structure was obtained by averaging 500 bootstrapped networks.



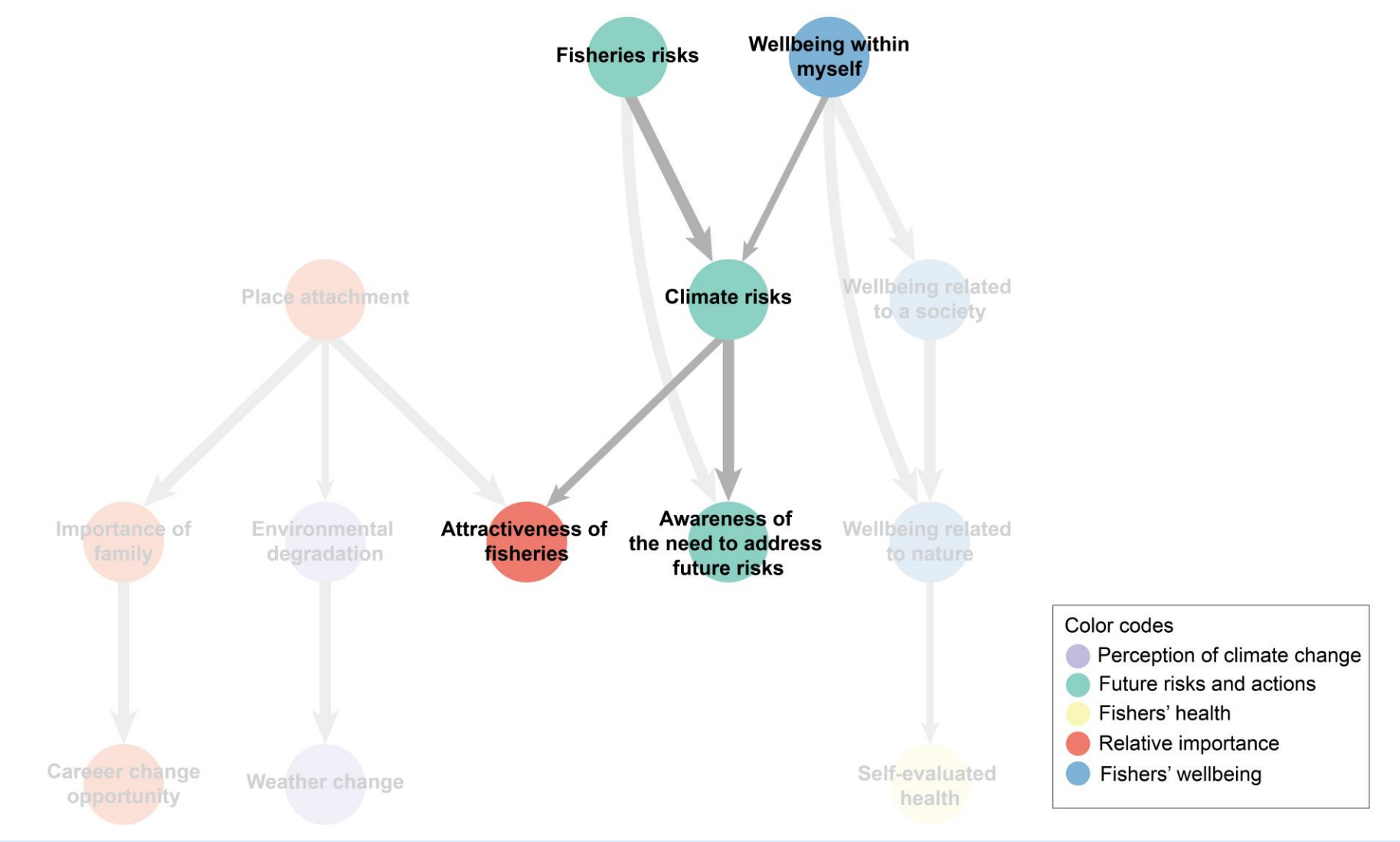
Results –relationships between identified factors–

- “Place attachment” and “well-being within myself” have potential impacts on the whole network.



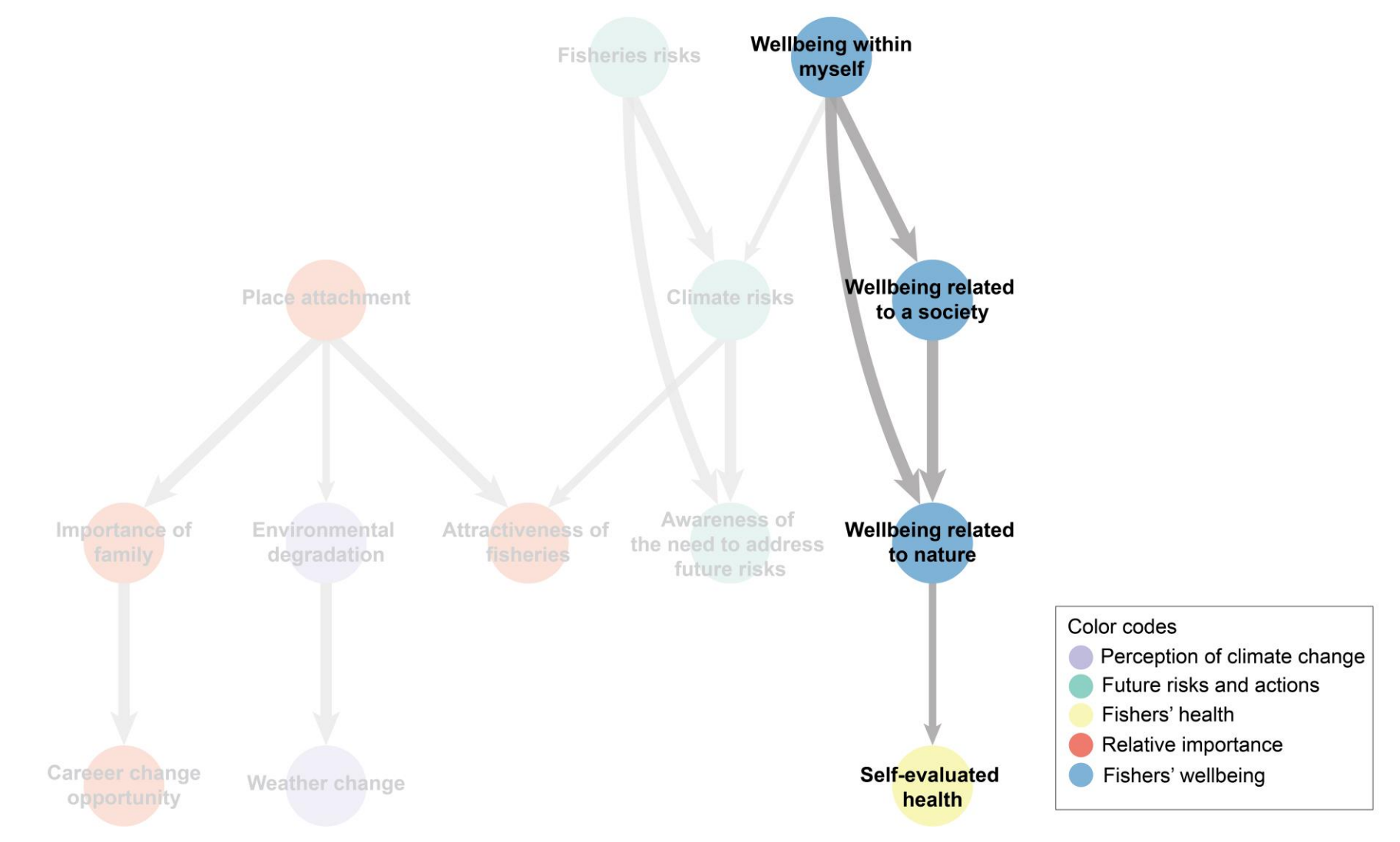
Results –relationships between identified factors–

- Fishers' anticipation of "climate risks" acts as a mediator (with the highest harmonic centrality score).



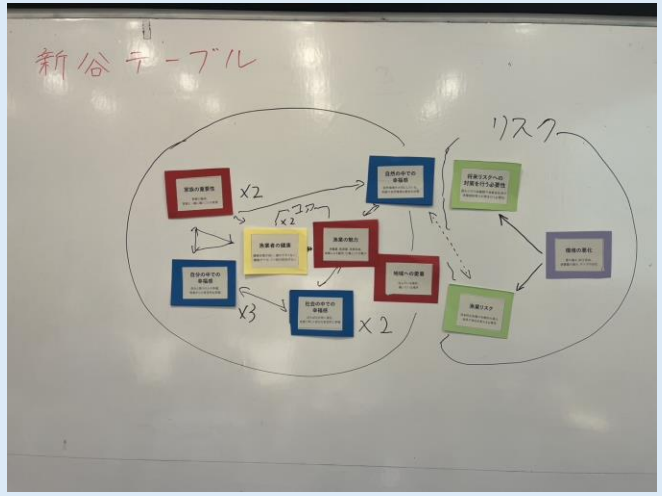
Results –relationships between identified factors–

- Only “well-being related to nature” is directly connected to fishers’ health.



Future directions

- Discussing how the findings can inform policy design and implementation.
- Compare the results of the statistical analysis with opinions from the focus group workshops held on September 11th.




Thank you for your kind attention.
I’d be happy to take any questions!