

Introducing an Innovative Model in Forestry

Integrating risk, economics and digitalization for sustainable forest management

Wildfire Risk & Economics Laboratory (WREL)

Todor Stoyanov • Nikolay Neykov



Why forestry needs an integrated model

02

Climate-driven disturbances now interact with economic and social pressures

Extreme wildfire

Higher frequency, intensity and spatial extent

Broader values at risk

Timber, infrastructure, ecosystem services and communities

Fragmented decisions

Risk models, economics and governance often remain separate

Research need

A unified framework that turns spatial risk into economically justified prevention priorities

Wildfire science

Hazard and fire
behaviour

Forest economics

Losses and ecosystem
values

Digital forestry

GIS, remote sensing
and DSS

Governance

Institutions and public
policy

Objective

Develop a conceptual model that integrates wildfire risk assessment, economic valuation, digital technologies and governance into one decision-support framework.

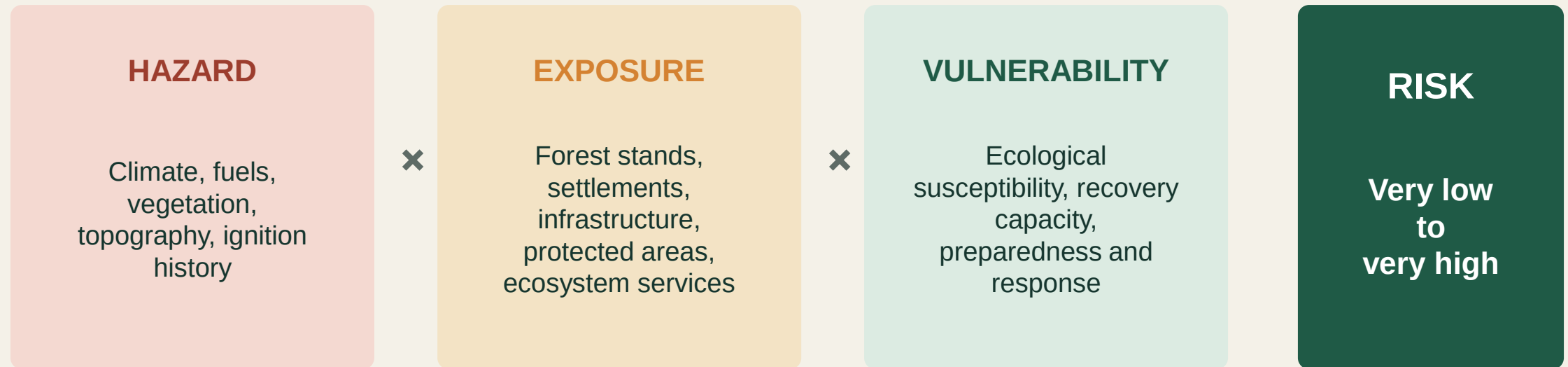
The WREL analytical chain

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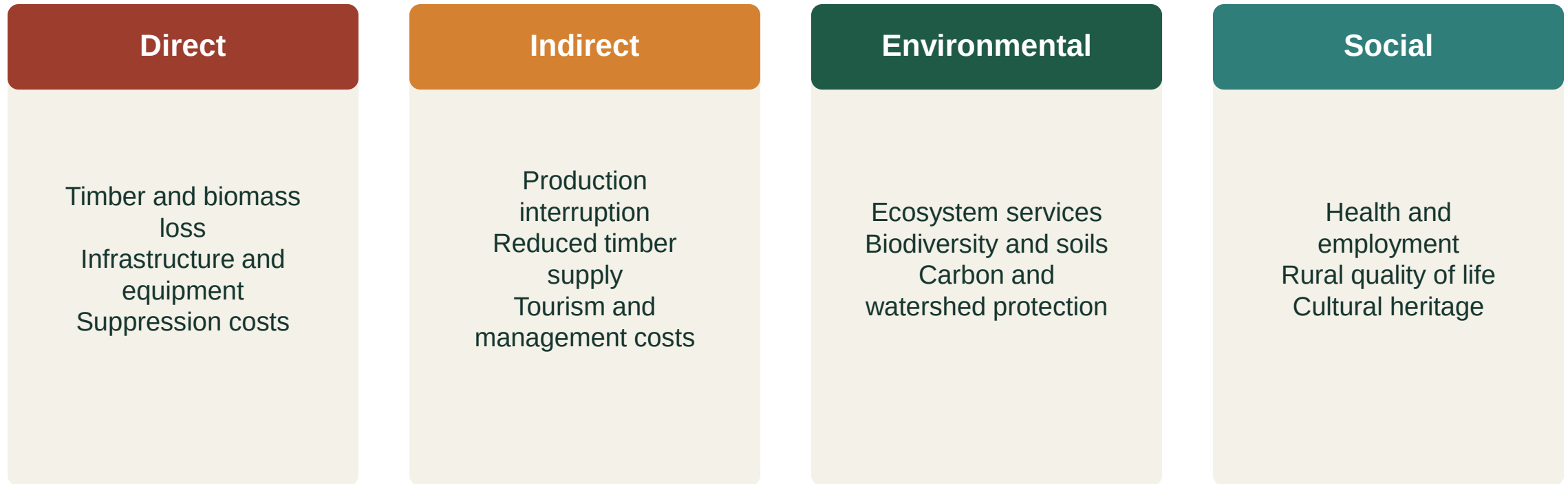


Continuous feedback supports adaptive forest management

WREL treats wildfire management as a continuous decision process, not as isolated emergency actions.



$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability}$$



Perpetual rent estimates the present value of future ecosystem benefits permanently lost after catastrophic fire.

GIS databases

Satellite observations

UAV monitoring

Meteorological data

Fuel maps

Forest inventory

Economic databases

Policy indicators

Integrated analytical environment

Dynamic spatial risk maps and economic prioritization scenarios

Adaptive management

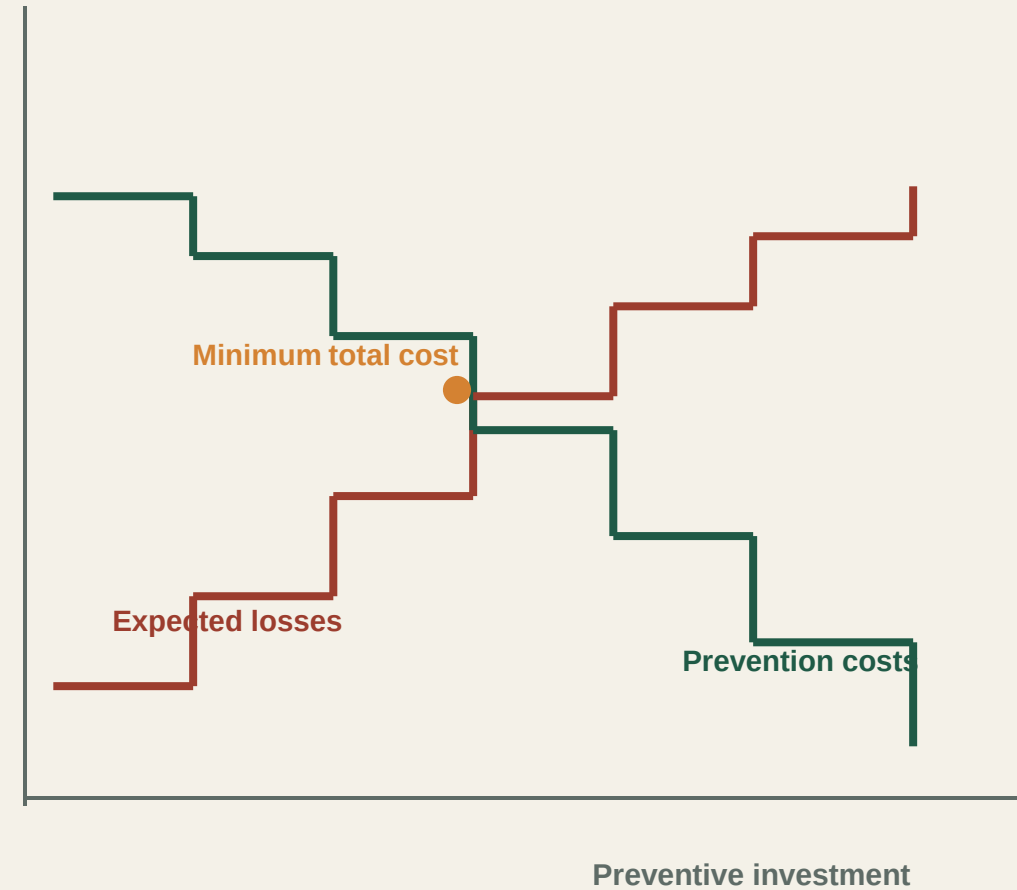
Evidence-based allocation

Future AI optimization

Prevention becomes an investment decision

- Compare prevention costs with expected losses
- Include avoided damages and resilience gains
- **Select the investment level that minimizes total societal cost**

Societal cost



Conventional forestry and the WREL model

CONVENTIONAL	WREL INTEGRATED MODEL
Timber-oriented	Risk-oriented
Reactive	Preventive
Separate ecological assessment	Integrated ecological-economic assessment
Static planning	Adaptive management
Manual analysis	Digital decision support
Post-fire recovery	Prevention optimization
Local information	Multilevel governance
Limited economic analysis	Full ecosystem-service valuation

Conceptual architecture of WREL

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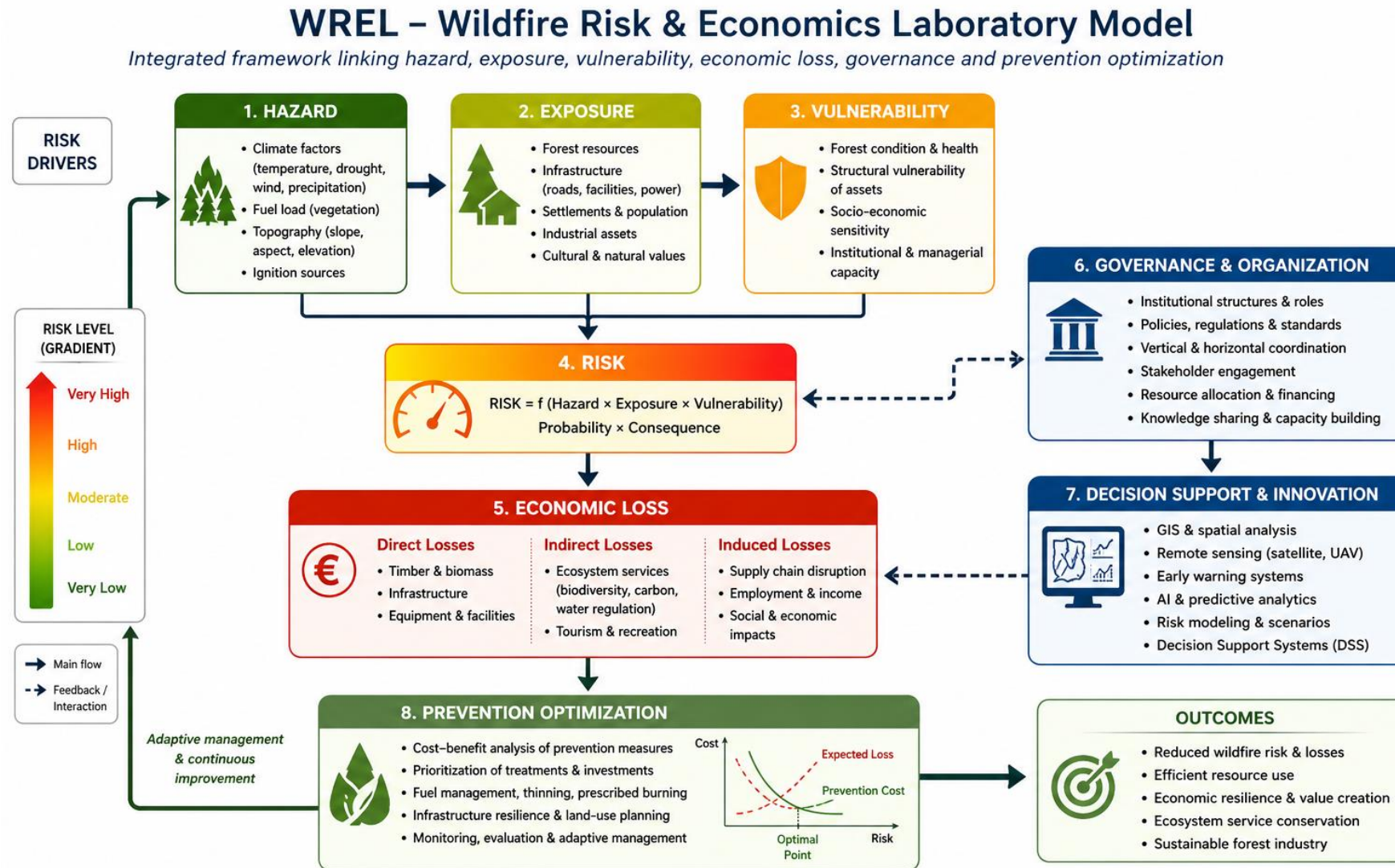


Figure 1. Integrated WREL (Wildfire Risk & Economics Laboratory) model linking hazard, exposure, vulnerability, economic loss, governance, innovation and prevention optimization in the forest sector.

Risk gradient: Low High

Application across governance levels

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The same framework supports operational choices and strategic policy.

THEORETICAL

**Links wildfire science,
economics, digital
forestry and adaptive
governance**

METHODOLOGICAL

**Combines spatial risk,
ecosystem valuation,
cost-benefit analysis
and multilevel
governance**

PRACTICAL

**Prioritizes preventive
investment and
strengthens strategies,
budgets and future AI
systems**

European policy alignment

EU Forest Strategy for 2030

European Green Deal

EU Climate Adaptation Strategy

EU Biodiversity Strategy

Circular Bioeconomy Strategy

Fire-Adapted Europe

Bioeconomy effect

Lower wildfire losses preserve biomass flows, carbon storage and ecosystem resilience.

Prevention therefore supports the long-term competitiveness of forest-based industries and more efficient use of biological resources.

Risk reduction strengthens the resource base

Conclusions and future research

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1

Economic valuation extends risk assessment beyond biophysical indicators

2

Digital data become more useful when linked to governance and economic priorities

3

Prevention optimization can reduce long-term losses and strengthen resilience

NEXT STAGE

AI prediction
Digital forest twins
Real-time UAV and satellite
monitoring
Copernicus integration
Carbon accounting
Multihazard assessment
Cloud-based DSS

WREL supports the shift from reactive suppression to proactive, economically justified and climate-resilient forest governance.

An aerial photograph of a vast landscape at sunset. In the foreground, a dense forest of tall evergreen trees covers a hillside. A winding road or path is visible through the trees. To the right, a calm lake reflects the golden light of the setting sun. In the background, rolling hills and mountains are visible under a sky with scattered clouds. The sun is low on the horizon, creating a warm, orange glow across the scene.

THANK YOU FOR THE ATTENTION!