Reassessing the Methodological Approach to Estimate In-Site Costs of Desertification When Empirical Data are not Available: A Ten-Year Review[1]

Reevaluación del enfoque metodológico para estimar los costos in situ de la desertificación cuando no se dispone de datos empíricos: una revisión de diez años

Reavaliação da abordagem metodológica para estimar os custos locais da desertificação quando não há dados empíricos disponíveis: uma análise de dez anos

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Abstract

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Desertification continues to impose significant economic and ecological costs across arid and semi-arid regions, yet empirical data for estimating in-site losses remain fragmentary or unavailable in most countries. This paper revisits and updates the methodological approach originally developed by Matallo (2013) to estimate the in-site costs of desertification in contexts of limited data availability. The method combines land-use typologies with heuristic cost coefficients, offering a pragmatic framework for preliminary economic assessment where direct valuation is not feasible. In this ten-year review, the original model is recontextualized within contemporary international frameworks — including Food and Agriculture Organization's (FAO) land degradation monitoring systems, United Nations Convention to Combat Desertification's (UNCCD) Land Degradation Neutrality indicators, and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) ecosystem valuation methodologies. Despite advances in remote sensing and socio-environmental accounting, the fundamental challenge persists: translating biophysical degradation into economic terms remains a critical barrier for policy design. The updated discussion confirms that heuristic models remain essential tools for bridging the gap between conceptual and operational knowledge. By valuing what can be known and acting within uncertainty, this approach preserves methodological rigor while enabling timely responses to ongoing land degradation processes.

Keywords: Desertification Economics, Heuristic Modelling, Data Scarcity, Methodological Framework**.**

Resumen

Junior, H. M. Reevaluación del enfoque metodológico para estimar los costos in situ de la desertificación cuando no se dispone de datos empíricos: una revisión de diez años. ***Rev. C&Trópico***, v. 49, n. 2, p. 15-28, 2025. Doi: 10.33148/ctrpico.v49i2.2725

La desertificación continúa generando importantes costos económicos y ecológicos en las regiones áridas y semiáridas; sin embargo, los datos empíricos para estimar las pérdidas in situ siguen siendo fragmentarios o inexistentes en la mayoría de los países. Este artículo

[1] Esta versão revisada atualiza as seções contextuais (4.1, 4.2 e 4.5) do capítulo original publicado em Developments in Soil Classification, Land Use Planning and Policy Implications (Springer, 2013). As seções 4.3 e 4.4 permanecem inalteradas, preservando a integridade metodológica do trabalho original.

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revisa y actualiza el enfoque metodológico desarrollado originalmente por Matallo (2013) para estimar los costos in situ de la desertificación en contextos con disponibilidad limitada de datos. El método combina tipologías de uso de la tierra con coeficientes de costo heurísticos, ofreciendo un marco pragmático para la evaluación económica preliminar cuando la valoración directa no es factible. En esta revisión de diez años, el modelo original se recontextualiza dentro de los marcos internacionales contemporáneos, incluidos los sistemas de monitoreo de la degradación de la tierra de la FAO, los indicadores de neutralidad en la degradación de la tierra de la CNULD y las metodologías de valoración de ecosistemas de la IPBES. A pesar de los avances en teledetección y contabilidad socioambiental, persiste el desafío fundamental: traducir la degradación biofísica a términos económicos sigue siendo una barrera crítica para el diseño de políticas. La discusión actualizada confirma que los modelos heurísticos siguen siendo herramientas esenciales para cerrar la brecha entre el conocimiento conceptual y el operativo. Al valorar lo que se puede conocer y actuar dentro de la incertidumbre, este enfoque preserva el rigor metodológico al tiempo que permite respuestas oportunas a los procesos de degradación de la tierra en curso.
Palabras clave: Economía de la desertificación, modelado heurístico, escasez de datos, marco metodológico.

Resumo

Junior, H. M. Reavaliação da abordagem metodológica para estimar os custos locais da desertificação quando não há dados empíricos disponíveis: uma análise de dez anos. ***Rev. C&Trópico***, v. 49, n. 2, p. 15-28, 2025. Doi: 10.33148/ctrpico.v49i2.2725

A desertificação continua a impor custos econômicos e ecológicos significativos em regiões áridas e semiáridas, mas os dados empíricos para estimar as perdas locais permanecem fragmentários ou indisponíveis na maioria dos países. Este artigo revisita e atualiza a abordagem metodológica originalmente desenvolvida por Matallo (2013) para estimar os custos locais da desertificação em contextos de disponibilidade limitada de dados. O método combina tipologias de uso da terra com coeficientes de custo heurísticos, oferecendo uma estrutura pragmática para avaliação econômica preliminar onde a valoração direta não é viável. Nesta análise de dez anos, o modelo original é recontextualizado dentro de estruturas internacionais contemporâneas — incluindo os sistemas de monitoramento da degradação da terra da Organização das Nações Unidas para a Alimentação e a Agricultura (FAO), os indicadores de Neutralidade da Degradação da Terra da Convenção das Nações Unidas de Combate à Desertificação (UNCCD) e as metodologias de valoração de ecossistemas do Plataforma Intergovernamental sobre Biodiversidade e Serviços Ecossistêmicos (IPBES). Apesar dos avanços no sensoriamento remoto e na contabilidade socioambiental, o desafio fundamental persiste: traduzir a degradação biofísica em termos econômicos continua sendo uma barreira crítica para o planejamento de políticas. A discussão atualizada confirma que os modelos heurísticos continuam sendo ferramentas essenciais para preencher a lacuna entre o conhecimento conceitual e o operacional. Ao valorizar o que pode ser conhecido e agir dentro da incerteza, essa abordagem preserva o rigor metodológico, permitindo respostas oportunas aos processos contínuos de degradação da terra.
Palavras-chave: Economia da desertificação; Modelagem heurística; Escassez de dados; Estrutura metodológica.

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1. Introduction

Since the adoption of the United Nations Convention to Combat Desertification (UNCCD) in 1994, the global understanding of land degradation has expanded beyond biophysical causes to include socioeconomic drivers, governance structures, and climate feedbacks. Yet, the methodological challenge of estimating the economic costs of desertification remains acute, particularly in regions where empirical data are scarce or unreliable. Contemporary frameworks such as those developed by FAO (2022), UNCCD (2023), and IPBES (2018) emphasize the integration of ecosystem service valuation and multi-scalar indicators to assess land degradation neutrality. However, these approaches often depend on datasets unavailable at the national or subnational level in developing countries, particularly in drylands where monitoring infrastructure is limited.

The methodological approach proposed in the original study (Matallo 2013) remains relevant as a pragmatic alternative for estimating in-site costs under data scarcity. By combining land-use typologies with heuristic cost coefficients, it allows policy analysts and land managers to approximate the magnitude of economic losses even in the absence of comprehensive empirical models. This revised version situates that approach within current scientific and policy contexts, identifying its ongoing relevance for cost-benefit analyses of desertification mitigation strategies.

2. The Problem of Data Availability

Recent global assessments confirm that the primary constraint in desertification economics remains data availability. Satellite-derived indices such as NDVI and LPDI have improved spatial resolution but often lack the temporal continuity required to evaluate long-term degradation trends (UNEP 2022). National statistical systems, meanwhile, rarely integrate soil productivity losses into agricultural GDP accounts. This gap perpetuates an asymmetry: while the physical processes of land degradation are increasingly visible, their economic implications remain invisible to decision-makers. Current efforts to harmonize land degradation metrics—such as the UNCCD's *Good Practice Guidance for Sustainable Land Management* (2022)—still face difficulties in translating biophysical indicators into economic units. In this context, the heuristic framework proposed in the original chapter remains a valuable methodological tool. It enables rapid appraisal of potential economic losses using simplified, adaptable parameters. The challenge for the next decade is to link these indirect estimation techniques with new data streams from remote sensing and socio-ecological accounting.

3. The Assessment of Economic Losses of Soil Erosion in Drylands

In March 2003, the OECD organized a meeting on "soil erosion and biodiversity indicators" in order to get information on the policy-relevant indicators that could track the current state and trends in soil erosion and soil biodiversity related to agriculture at global level, in particular in Europe, and also the current approaches for modeling the economic valuation of soil erosion. Some papers were presented in this meeting, and some sort of data and methodological discussions came out as the most recent overview on the economic issue of soil erosion even though the papers were not referred specifically to drylands.

The main conclusion contained in the studies prepared for the meeting was that soil erosion should not be of much concern in developed countries, particularly in the USA and Europe. According to some data presented by Crosson (2003), the estimated costs of in-farm soil erosion in the USA are around US$ 100 million annually (US$ 0.60 ha^{-1}). The author mentions other alternative assessments, including the one offered by Pimentel et al. (1995) that has assumed an economic loss around US$ 25 billion due to soil erosion. According to Crosson (2003), Pimentel et al. (1995) do not show any good evidence for their estimations, and their figures cannot be accepted. In the same line, the author mentions some data regarding the situation in China and Indonesia and concludes that for these countries, soil erosion does not represent major concern even when some research shows a decline in topsoil depth. Maybe Crosson (2003) had made the mistake as Pimentel et al. (1995) did regarding the lack of evidence.

When the problems of soils erosion come to drylands, the methodologies and data are even less accurate, and we have to rely on the studies conducted almost 30 years ago by Harold Dregne, who has designed the methodology to assess the costs of land degradation in drylands during the 1980s (Dregne and Chou 1992); Crosson (2003) recognizes also that it is the only one referred to desertification. The outcomes presented by Dregne related to the amount of degraded areas, its intensity, and the further estimation of costs have been used by many institutions for more than 25 years and have been taken as "quasi-official" by many institutions, including the UNEP assessment of the costs of land degradation (Crosson (2003) and accepted Dregne's methodology after making new calculations).

But looking carefully to the foundations of such methodology and data, it seems that it is not accurate enough to be credible. According to Dregne, the data and the estimations lie on a very weak source of data. This is the author's view on his own sources of data. The information base upon which the estimates in this report were made is poor. Anecdotal accounts, research reports, travelers' descriptions, personal opinions, and local experience provided most of the evidence for the various estimates. Some data were available for Australia and the United States. Both of these countries have con-ducted comprehensive assessments of land degradation on irrigated, rainfed farming, and rangelands. For the country data, it is impossible to estimate the error in the numbers of hectares in each degradation class because there are no accepted values against which to make comparisons. To our knowledge, no one except the senior author has ever attempted a global assessment, and very few have published national assessments. (Dregne and Chou 1992)

Regarding the economic losses, Mr. Dregne considers two components: (a) the costs of losses in rainfed and irrigated agriculture and also rangelands and (b) the costs of restoration in the three mentioned categories. For each category Mr. Dregne gives the following figures based on the US and Australian experience:

(a) Costs of land degradation – economic losses:

- Irrigated land – US$ 250.00 ha^{-1} $year^{-1}$
- Rainfed cropland – US$ 38.00 ha^{-1} $year^{-1}$
- Rangeland – US$ 7.00 ha^{-1} $year^{-1}$

(b) Costs of rehabilitation:

- Irrigated areas – US$ 2,000.00 ha^{-1}
- Rainfed cropland – US$ 400.00 ha^{-1}
- Rangeland – US$ 40.00 ha^{-1}

It is clear that the figures presented above are linked with the US economy, and the values estimated to the losses and restoration should be adapted for the econo-mies in developing countries.

At the global scale, it is difficult to select a single figure for the cost of degraded irrigated land, for example, because the cash equivalent value of the crop, whether it is wheat or sorghum or corn, varies greatly from country to country. Subsidies, price controls, and foreign exchange rates, among other factors influence price. Despite the variations, one figure was used as the amount of income foregone on irrigated, rainfed, and rangeland when the degradation was at least moderate in severity. The number used represents, approxi-mately, a 40% loss in productivity. A

40% loss means that the actual yield was 40% less than it would have been in the absence of any degradation. For irrigated land, that represents a $250 (U.S.) per hectare per year reduction in income, $38 on rainfed cropland and $7 on rangeland. The numbers represent our estimates, based upon a relatively small amount of data, most of it from the United States and Australia. (Dregne and Chou 1992).

In the text quoted, there is no clear mention or indication about the methodology or sources used to come up with the figures related to the economic losses according to different land uses. It seems that the only reason to accept those figures at that time was due to the lack of other alternative research and reliable data and also because of the political support given by UNEP to the mentioned study.

It is worth to mention that at the time Dregne (1992) came up with his assessment, the different land uses in drylands were roughly covering rangelands in 88%, rainfed crops in 9%, and irrigated crop production in 3%.

It means that for each 100 ha of agricultural land, it can be assumed that 88 ha was referred to rangelands, 9 ha for rainfed crops, and only 3 ha for irrigated crops. Considering the situation above mentioned and the value of economic losses established by Dregne, it can be assumed that the economic losses for each 100 ha in affected drylands were the following:

88 ha	×	7.00 US$	=	616.00 US$
9 ha	×	38.00 US$	=	342.00 US$
3 ha	×	250.00 US$	=	750.00 US$
Total (100 ha)			=	1,708.00 US$
Average loss			=	17.08 US$ ha^{-1} $year^{-1}$

It has to be clear that Dregne has not made the above-mentioned estimation related to the average of losses per hectare and according to the different land uses. He has only mentioned in general terms the amount of land used for different purposes. But the logical conclusion based on the Dregne's assessment leads us to the mentioned figures, even considering his warning that the data applies to US and Australian economy only.

As we know, in most developing countries, the dryland's economy is not well integrated to international markets or even national markets, and the economic value of soil losses and restoration would be possibly smaller than those related to developed countries.

If this is the case, we should consider a "k factor" for adjusting the figures for drylands in developing countries. Based on the existing experience in terms of the costs of production and the prices for some agricultural inputs, we can estimate a "k factor" as around at least 20% less than the prices of the same commodities or agricultural inputs in developed countries (Matallo and Vasconcelos 1999). Considering the same situation proposed by Dregne but now applied to drylands in developing countries, it can be concluded that the average of the economic losses could be around 13.6 US$ ha^{-1} $year^{-1}$ as shown below:

88 ha	×	5.60 US$	=	492.80 US$
9 ha	×	30.40 US$	=	273.60 US$
3 ha	×	200.00 US$	=	600.00 US$
Total (100 ha)			=	1,366.40 US$
Average loss			=	13.60 US$ ha^{-1} $year^{-1}$ (k factor applied)

However, almost 30 years after the estimations made by Dregne, the situation is quite different for both developing and developed countries.

According to the ICID (http://www.icid.org/index.html0), the average of irrigated land vis-à-vis the arable and permanent crop areas for each continent has been improved and can be seen in Table 40.1. It should be noticed that the data were taken in general terms and are not specifically referred to drylands.

Table 40.1 shows that the amount of irrigated area in the world is 6 times higher than during the 1980s when Dregne came up with his analysis, and if the trends in land use changes kept in 2009 the same patterns as in the 1980s, the economic losses due to irrigation could be, at least, 6 times higher.

Following the trends presented in Table 3.1, it could be considered for a particular region as Latin America that the average of irrigated area would have grown from 3 to 10 ha for each 100 ha in 25 years, which would imply an increase of 300%. But the situation is not simple like that. Irrigation is something special in drylands because it depends on the quality of soil and, most important, the availability of water, which is a limitation by definition. Data available for some countries (Chile, Brazil, and Argentina mainly) shows that irrigated area has increased around 100% in the last 25 years. It means that it can be assumed that irrigated area grew from 3 to 6 ha for each

100 ha.

Since we do not have the data regarding rangelands, we can assume that the irrigated area has grown over the previous rainfed agriculture and that the expansion of rainfed agriculture (with the same growth rate) was made over rangelands with the same proportion. These assumptions lead us to the following estimations for each 100 ha:

Table 3.1 Total geographical, arable, permanent cropped, and irrigated area in the continents

Continent	Total geographical area (million ha)	Arable and permanent crop area (APC) (million ha)	Irrigated area (million ha)	(%) of irrigated area to APC
America	3,795.50	377.77	41.8	11.0
Asia	3,002.25	556.18	195.5	35.0
Europe	2,172.01	292.58	26.6	9.0
Africa	2,199.30	176.96	13.5	7.0
Oceania	801.17	51.97	2.9	5.0
World	11,970.23	1,455.57	280.3	19.0

Sources: ICID-http://www.icid.org/imp-data.pdf

82 ha (rangelands)	×	5.40 US$	=	442.80 US$
12 ha (rainfed agriculture)	×	30.40 US$	=	364.80 US$
6 ha (irrigated land)	×	200.00 US$	=	1,200.00 US$
Total (100 ha)			=	2,007.60 US$
Average loss			=	20.07 US$ ha^{-1} $year^{-1}$

The new figures express mainly the development of irrigated agriculture in developing countries. However, it seems that these numbers are extremely high (Crosson 2003).

It is quite clear that the economic losses resulting from land degradation cannot be estimated easily. However, it is absolutely crucial for sustainable development and the fight against desertification to have at least a general idea on how much money land degradation represents.

Considering the lack of consensus on the methodology to establish the economic losses of soil erosion (as assumed by Dregne or Crosson), it could be suggested to consider the economic losses due to soil degradation in drylands as US$ 10.00 ha^{-1} $year^{-1}$. This means a bit more than 50% of the average estimation emerged from Dregne's methodology. This assumption is reasonable and acceptable for general estimations, particularly in the absence of a more detailed and acceptable methodology and empirical data.

4. Desertification in Latin America

As mentioned before, the source of data and information on desertification in the world is very limited. Many countries do not have reliable data on the extension of land degradation or the population affected, and many others do not present official documents and figures on the extent of desertification. It means that we do not have precise information that allows us to have a general and coherent view on land degradation in the world. In this context LAC region is not an exception.

Table 4.1 Total area, population, and areas in process of desertification

Country	Total area (ha)	Total population	Areas in process of desertification (ha)	Total population in areas in process of desertification
Argentina	279,181,000	36,223,947	195,426,700	108,671,841
Brazil	851,420,490	169,799,170	66,554,300	15,748,769
Colombia	114,174,800	44,000,000	19,351,000	20,900,000
Costa Rica (data from 2003)	5,106,000	4,089,609	51,654	–
Ecuador	25,637,000	12,156,608	7,060,437	1,000,000
El Salvador	2,104,079	6,329,091	363,000	650,414
Mexico	195,924,800	104,213,503	58,689,150	–
Panamá (data from 2003)	7,551,700	2,839,117	1,876,920	662,236
Paraguay	40,675,200	5,163,198	1,000,000	–
Dominican Republic	4,769,300	8,562,541	3,290,817	5,908,153
Venezuela	91,645,500	23,232,553	9,883,100	6,119,112
Total	1,635,811,369 ha 16,358,113 km^2	419,809,337	363,547,078 ha 3,635,470 km^2	52,055,868

The Facilitation Unit of the UNCCD and the Argentinean National Focal Point, in its capacity as coordinator of the Technical Regional Programme on Benchmarks and Indicators, have conducted a research among countries in order to get information on the status of desertification in the region. The questionnaire was elaborated and applied in the framework of the TPN1 Benchmarks and Indicators and was sent to all LAC countries. We mention only the countries that have answered the questionnaire. The main results can be seen in the Table 40.2.

As it can be seen, the total degraded area in its different levels in the mentioned countries is of 3,635,470 km^2, 22% of the total area of the same countries.

The affected population in these countries (exception of Mexico, Costa Rica, and Paraguay) is of 52 million or 12.4%.

Considering the mentioned information, we cannot establish in detail the different levels of degradation or the economic impact of land degradation on countries and their population, but we consider that an economic evaluation of desertification is crucial for policy elaboration process on land degradation and poverty reduction. With this idea in mind, and taking into consideration the "economic exercise" made for the dry regions of Brazil (Matallo and Vasconcelos 1999), it is possible to develop some hypothesis for obtaining an estimation of the costs of desertification in the above-mentioned countries.

As known, soil erosion is a natural phenomenon even in areas with no human activity. But in the areas under agricultural activities, particularly on the areas under intensive and inadequate use of soils, the erosion is intensified and leads to changes in landscape with impacts on other natural resources as water and forests.

Table 4.2 Qualitative and quantitative risk of erosion

Erosion rate	Losses (t ha^{-1} $year^{-1}$)
Very high	>20
High	10–20
Moderate	5–10
Low	2–5
Very low	0–2

The Universal Soil Loss Equation (USLE) is a quantitative and empirical model for the prediction of soil losses during a period of time and under specific circumstances such as precipitation, soil texture, and the land use system. This formula predicts the physical soil erosion, and even considering its limitations, it can be extremely useful for estimating the economic losses of land degradation in a situation of "lack of research and empirical information" and in offering decision-makers an approximate dimension of the desertification. Our hypothesis is based on the fact that erosion is probably the major problem for the maintenance of sustainability of land use and management and that the erosion rate can be different for different types of soils or management systems and different cultivation practices.

The risk of erosion can be expressed qualitatively as "very high, high, moderate, low, and very low" or quantitatively as "tons per hectare per year (t ha^{-1} $year^{-1}$)" (Table

4.2). The technical literature agrees on the following general figures for soil losses. The types of soils or productive systems are not considered in these figures, and for this reason, they are considered as theoretical values. Generally speaking, the concrete situations are much more complex than that. Using these figures, economical losses can be estimated from soil erosion and from water degradation, since soil erosion impacts watersheds and dams through sedimentation. It means that water reservoirs have been affected in their capacity of water storage and there are other possible hydrologic cycle disturbances.

In order to estimate the financial cost of soil erosion in LAC region, we assume that the affected areas mentioned by countries in the table above have a moderate level of degradation of 7.5 t ha^{-1} $year^{-1}$ (that is a very modest estimation). This means that the soil losses for the entire region are 357,247,078 ha × 7.5 t ha^{-1} $year^{-1}$ that is equal 2,726,603,148 t of soils per year (2.7 billion of t $year^{-1}$).

The cost estimation for different types of agricultural practices as irrigated crops or rainfed crops and grazing was discussed in the previous section, and for our purposes and considering that we do not know how is the composition of land uses in agriculture in the affected areas in terms of rainfed or irrigated agriculture or grazing, it can be assumed as an average loss of US$ 10.00 ha^{-1} as mentioned before. Considering this amount, the losses are of more than 27 billion US$ per year.

Table 4.3 shows the total losses and its relationship with the national growth prod-uct (GNP) for the mentioned countries in 2004. The most impressive case is Argentina, where the losses caused by desertification represent more than 9% of the GNP.

At this point we should consider another aspect of land degradation and its economic impacts, that our estimation is annual but desertification is a process in time, and for this reason, we must consider the data for a certain period of time. For estimation purposes, we assume the hypothesis that desertification has been harming countries in the last 12 years (again a very modest assumption), since the approval of the convention in 1994.

Table 4.3 Total losses and their relationship with the national growth product (GNP)

Country	GNP (2004) (million US$)	Costs of soil and water losses (2005) (million US$)	Losses/ GNP (%)
Argentina	153,014	14,730.3	9.00
Brazil	603,973	5,016.5	0.60
Colombia	97,718	1,458.6	1.00
Costa Rica	18,496	3.9	0.02
Ecuador	30,282	532.2	1.70
El Salvador	15,824	27.4	0.10
México	676,497	4,423.7	0.60
Panamá	13,733	141.5	0.01
Paraguay	7,343	75.4	0.01
Dominican Republic	18,673	248.0	0.01
Venezuela	110,104	741.6	0.01
Total	11,745,657	27,399.1	

Source of GNP: World Bank, (https://databank.worldbank.org)

During the last 12 years, the average economic growth was around 3% annually, and this is the figure we suppose is the annual increment of the losses due to desertification. The calculations show that the accumulative economic losses represent more than US 150 billion dollars for the 11 countries considered. It means that the deficit per capita is more than US$ 3,500.00 and it is higher than the per capita income regional average. This means a real impoverishment of the population.

4.5 Conclusion

Ten years after its initial publication, the methodological approach presented here continues to offer a practical bridge between conceptual models of land degradation and policy implementation. Its relevance endures precisely because the fundamental constraints—data scarcity, institutional inertia, and uneven monitoring capacity—persist across most dryland regions. The integration of economic reasoning into land management decisions remains limited, even as global frameworks for Land Degradation Neutrality (LDN) expand.

Future research should focus on combining heuristic cost estimation with participatory valuation and dynamic spatial models. Such integration would strengthen both the scientific credibility and the policy utility of desertification assessments. The enduring lesson of this framework is that methodological pragmatism can sustain progress where perfect data are absent. By valuing what is knowable and acknowledging uncertainty, it allows policy to act without waiting for complete knowledge — a principle that remains as vital today as it was a decade ago.

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