

Review

A Global Review of Farmers' Perceptions of Agricultural Risks and Risk Management Strategies

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Abstract: Farmers around the world face and manage a wide range of enterprise-related risks. These risks are increasing due to a range of factors including globalisation, increased trade in agricultural products, and climate change, jeopardising agricultural enterprises and forcing farmers to adjust their production and management strategies. Here we present results of a systematic literature review, following PRISMA protocol, of farmers' perceptions of, and responses to, agricultural risks. Using data reduction method (factor analysis) and descriptive statistics, we analysed 197 studies and found that weather-related risk (55%), biosecurity threats (48%), and human risk (35%) are the significant risks perceived by farmers for their agricultural enterprises. Diversification of crop and animal production (28%) and pests and diseases monitoring and prevention (20%) were the preferred agricultural risk management strategies employed by farmers. Few studies have investigated socio-economic factors that explain risk perceptions (18%) or factors that influence how farmers manage agricultural risks (11%). The main barriers to successfully managing agricultural risks were limited access to information and formal low-interest loan systems, especially in developing countries. We identified a mismatch between perceived risk sources and risk management strategies, highlighting a need to improve understanding of why particular management responses are employed to address the various risks. This review suggests areas for future research to improve understanding of the perceptions of risks held by farmers, and to support efforts to manage and reduce these risks.

Keywords: review; risk sources; factor analysis; risk management strategies; perceptions

1. Introduction

Agricultural enterprise has always been at risk from factors such as pest and disease attack, uncontrollable weather events and market variability [1–3]. Many risks are now being exacerbated by global environmental, social, and economic change, including continued human population growth, limited arable land, land degradation, and climate change [4–6]. Agricultural risks come from different sources and are experienced to differing degrees across different geographic and political scales. Sources of agricultural risks have previously been classified into price or market risk (output and input price fluctuation, market shocks), financial risk (loans and credits), production risk (weather-related risk, pests and diseases (biosecurity threats), technology change, yields), institutional risk (regulations, legal, environment and tax policy), and human resource risk (physical and mental health) [7,8].

Farmers' management response to risks is influenced by their perceptions of the risk concerned [9]. Based on how they perceive risks, farmers implement a wide range of strategies to limit the impacts of

agricultural risks [1,10–12]. Farmers employ strategies including informal mechanisms at the farm level (crop and animal diversification and advanced technology applications) to formal mechanisms like insurance and contracting [13].

With different socio-economic backgrounds (age, education, culture, religion, farming practice, income, peer pressure, and community values) farmers' have different risk perceptions, resulting in different economic behaviours and decision-making [14,15], including response to risks. Farmer-level choices to adopt management strategies and successfully manage risks have been shown to be limited by many factors, including the absence of transparent information, limited institutional support, and lack of capital [16,17]. To enable improved institutional support relating to risk management, it is, therefore, essential to understand farmers' risk perceptions, the socio-economic factors that influence risk perceptions and likely response to risks, and the barriers to implementing management strategies [5,18–21]. For example, in recent years, research has investigated how farmers perceive agricultural risks, and how farmers respond to particular perceived risks [2,22], factors affecting farmers' perception and strategies [23–25], and barriers to risk management [26]. Those studies primarily focus on individual cases on crops and animals, ranging from developing countries [27] to developed countries [5] spanning Asia [28], Africa [29], and Europe [30].

While the existing literature has begun to tie these various concepts together in case studies, there has not, to date, been a systematic review of how these concepts are related, in the context of agricultural risks. The aims of this study are, therefore, to review the existing literature to identify (1) the major sources of agricultural risks perceived by farmers, (2) common risk management strategies employed by farmers, (3) linkages between risk sources and risk management strategies, (4) socio-economic factors that affect farmers' perceptions and management strategies, and (5) the barriers to the management of agricultural risks.

2. Materials and Methods

To address the research aims a systematic review of literature published in international peer-reviewed journals was undertaken using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol (see Moher et al. [31]).

2.1. Eligibility Criteria

Articles were included in this review, if they discussed (i) risk sources perceived by farmers or management strategies, (ii) farmers' management strategies, (iii) socio-economic factors affecting risk sources perceived by farmers or management strategies, (iv) any general barriers farmers perceived when operating farming enterprises, and (v) were written in English and peer-reviewed. Quantitative as well as qualitative studies were included, and no matter of the source of the data. Studies relating to farmers but not related to their perceptions towards agricultural risk sources, their management strategies, or factors affecting their perceptions were excluded (such as if they focused on agricultural conservation, sustainable agriculture, energy, or biomass). With the aim to achieve homogeneous data, it was assumed that farmers worked at a particular farm, so it was decided not to include the keywords *herders* and *pastoralists* in the search strategies.

2.2. Search Strategy

The keywords (*agricultur** OR *farm**) AND (*perception* OR *perceive**) AND *risk** were used to search titles, abstracts and keywords in Scopus to obtain articles published prior to 9 December 2017. It was decided not to set a start date so that search results could be able to capture any available studies prior to 9 December 2017. Asterisks were used to capture possible derivations of words. After filtering for English and peer-reviewed items, 2506 articles were obtained. The search was also conducted on Web of Science and Google Scholar and found an additional 124 and 66 articles, respectively. Of all 2696 articles, 94 duplicates were removed, leaving 2602 articles for title and abstract screening to confirm they fulfilled the inclusion criteria. The titles of each study were then screened using the keywords (*risk*

perception* OR risk management OR risk sources OR perceived risks) AND (animal OR crop) OR (farmers OR growers OR producers OR agriculture) resulting in the exclusion of 2081 articles. This process was conducted through a period of three months by the lead author. The remaining 521 full-text articles were then screened, and 324 articles were excluded as they did not meet the eligibility criteria. Studies discussing farmers' perceptions and management of biodiversity and natural resources, forestry and aquaculture were not included for further analysis. A remaining 197 articles were eligible for the review; 81 discussing farmers' perceptions on agricultural risk sources; 23 investigating farmers' risk management strategies, and 93 focusing on both those topics (Figure 1 and Table S1).

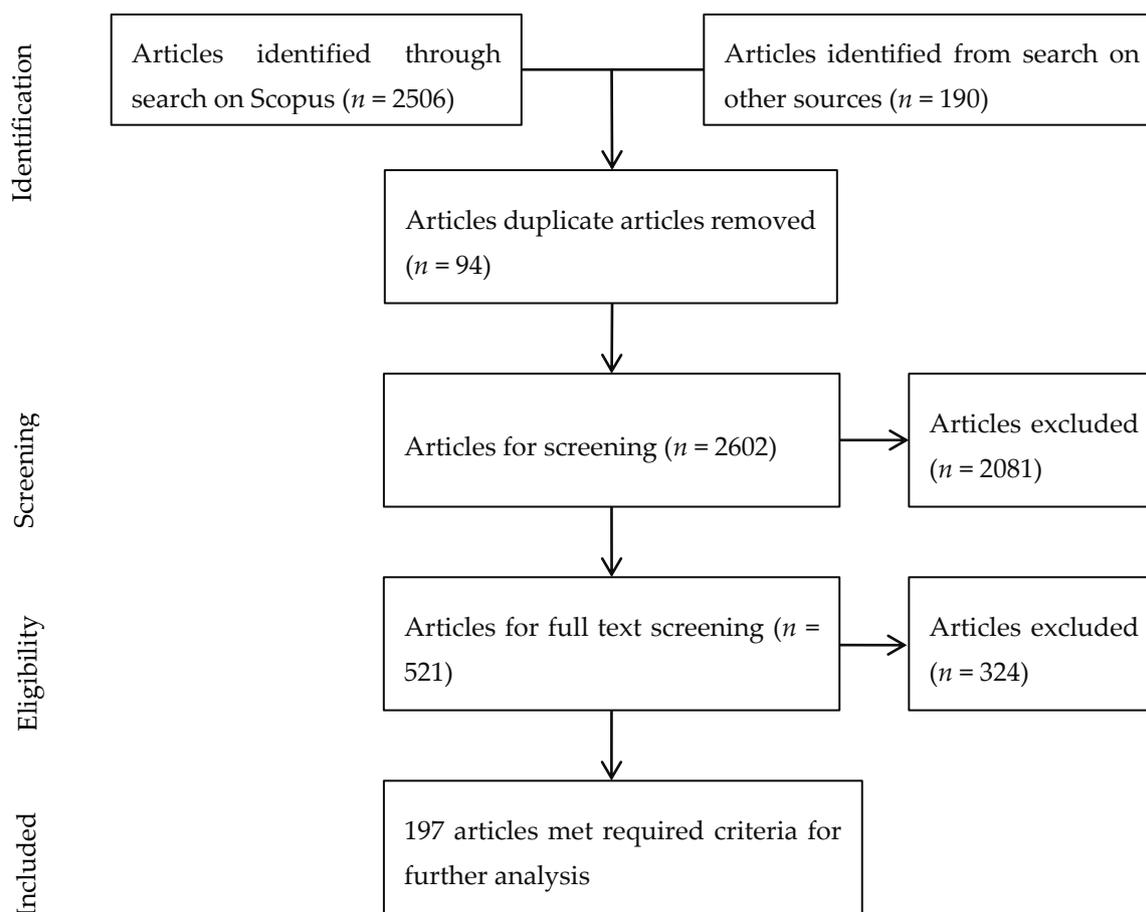


Figure 1. PRISMA review.

2.3. Categorisation

The reviewed literature was categorised into seven categories of risk. Five of the categories are widely used: output price and market risk, financial risk, production risk, institutional risk, and human risk [7,8,32,33]. Market risk includes input and output price fluctuation and any market shocks. Financial risk consists of loans, interest rates, and relates to the financing of farms. Production risk mainly originates from unpredictable weather events, pest and disease attack (biosecurity), yield loss, and technological risk. Institutional risk comprises unfavourable government-enforced changes in policy, rules, tax, and regulations. Human risk is associated with the farm owners or farmers, in the event of death and sickness, which may result in the loss of profit or the sustainability of the farming business.

Production risk is the significant risk source [34], as agricultural production and food security have been increasingly influenced by climate change and pests and diseases [35–38]. Thus, further distinctions were made by breaking down production risk into a sixth category, *weather and climate change risk*, which is often part of weather-related risk, and a seventh category, *biosecurity threats* (such

as pest and disease outbreak, invasive species). Following the categorisations of the World Bank [13] and Hay [39], technological risk was a main risk within production risk and thus could be categorised as one group of risk. There were, therefore, a total of seven categories of risk sources.

2.4. Data Analysis

Firstly, to explore the nature and trend of risk sources and risk management strategies, the data were analysed using descriptive statistics and Factor Analysis with Kaiser Mayer Olkin normalisation and Varimax rotation [40]. Statistical tests were performed with SPSS (Version 25, IBM, New York, NY, USA). Secondly, to uncover linkages between particular risks and risk management strategies, factor analysis was used along with Spearman's Rank Correlation analysis. Thirdly, the factors affecting farmers' perceptions of risk sources, risk management strategies, and barriers to managing agricultural risks were summarised based on the aggregated data from descriptive statistics.

3. Results

3.1. Snapshot of Selected Studies

The number of studies on farmers' perceptions of agricultural risks and their management strategies has increased notably over time, particularly from 2010, onwards (Figure 2).

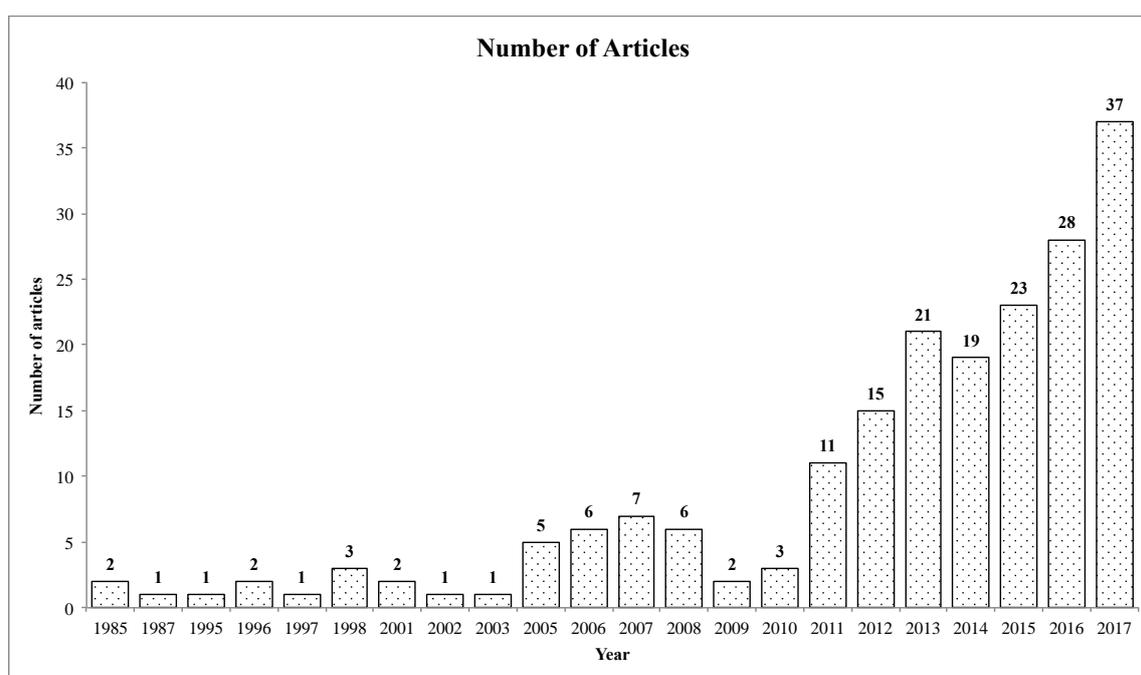


Figure 2. Number of articles on farmers' perception of risk sources and risk management strategies over the period 1985–2017s ($n = 197$). Numbers above bars are the number of articles.

Studies were predominantly conducted in Asia (29%), followed by America (25%), Europe (22%), Africa (19.5%), and Oceania (4.5%). More than half of the studies (54%) explored agricultural risks in the crop sector, while there were 27% in the animal sector, and 19% in mixed production sectors (both crop and animal). Based on the classification of the United Nations (2014), 57% of the studies were conducted in developing countries. Surprisingly, of the obtained 197 studies, there was no study conducted across both developing and developed countries. Of the studies, 41% (81 studies) only dealt with farmers' agricultural risk perceptions, 12% (23 studies) only with risk management, and 43% (93 studies) focused on both perceptions of agricultural risks and management responses to agricultural risks. Findings showed that all studies in this review presented results from analysing primary data.

3.2. Agricultural Risk Perceived by Farmers

In general, more than half (55%) of the studies reported that farmers perceived weather and climate change as the main risk to their farm enterprises, followed by biosecurity threats (48%), human risk (35%), and market risk (27%), while technology was least frequently mentioned (Figure 3). Weather risk, human risk, and biosecurity threats were the most frequently cited risks by the farmers in the crop sector. In the animal sector, biosecurity threats, weather risk, and human risk are the most frequently cited. In the mixed production sector (crop and animal), the most cited risks in studies were weather risk, biosecurity threats, and market risk (Figure 4).

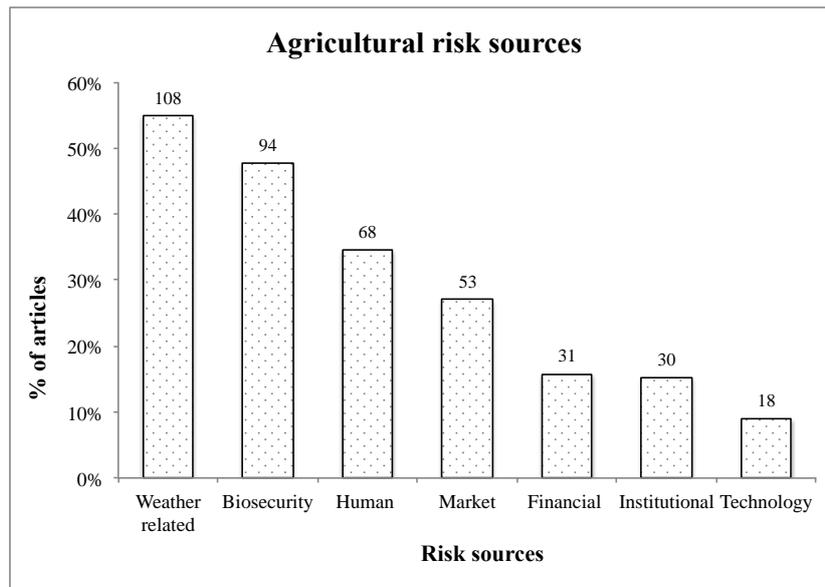


Figure 3. Distribution of agricultural risk sources as identified in the review ($n = 174$). Numbers above bars are the number of articles studying risks.

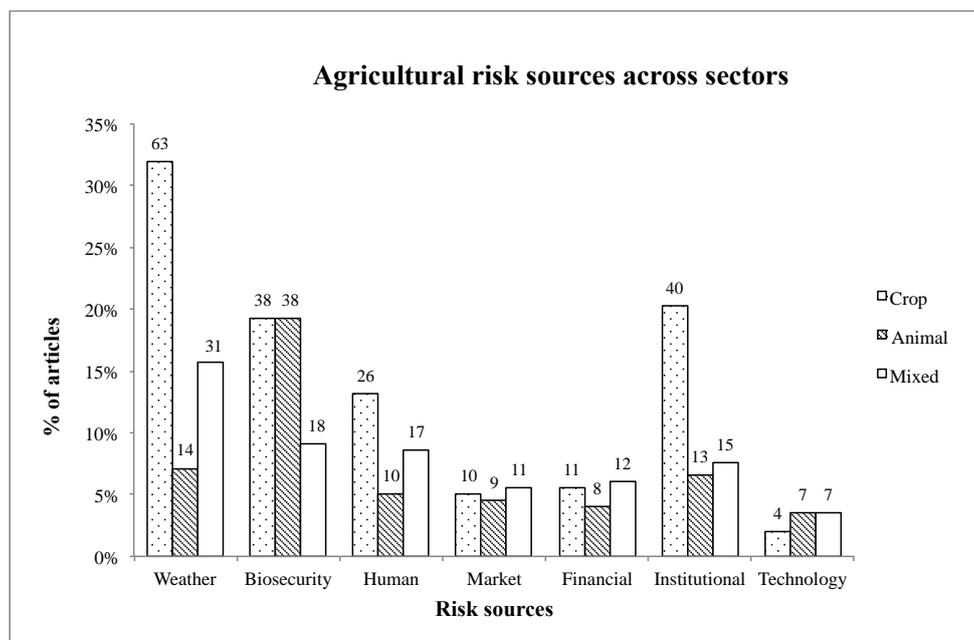


Figure 4. Distribution of agricultural risk sources across three sectors ($n = 174$). Numbers above bars are the number of articles discussing risk sources across sectors.

There were notable differences in farmers' perceptions of risk source between studies in developing countries and developed countries. Weather-related risk, biosecurity threats, and human risk were mostly cited in developing countries while in developed countries biosecurity threats was the most cited, followed by weather-related risk and human risk (Table 1).

Table 1. Number of studies citing risk sources perceived by farmers in developed and developing countries ($n = 197$).

Countries	Developing ($n_1 = 112$)		Developed ($n_2 = 85$)	
Weather related	$n = 75$	67%	$n = 33$	39%
Biosecurity	$n = 48$	43%	$n = 46$	54%
Human	$n = 41$	37%	$n = 27$	32%
Market	$n = 30$	27%	$n = 23$	27%
Financial	$n = 16$	14%	$n = 15$	18%
Institutional	$n = 10$	9%	$n = 20$	24%
Technology	$n = 8$	7%	$n = 10$	12%

Factor analysis of perceived risks explained 77.52% of the total variance across three components (Table 2). The factor model had a Kaiser Mayer Olkin measure of 0.780 and a Bartlett's Test of Sphericity of ($p < 0.001$). The first component, labelled *direct risks to production*, was the most strongly comprised of "human risk", "market risk", "financial risk", "institutional risk" and "technology risk". The second and third components were comprised of *weather* and *biosecurity*, respectively.

Table 2. Results of factor analysis on farmer's perceptions of agricultural risk sources ($n = 174$) (Varimax rotated, Coefficient values ≥ 0.5 in bold).

Risk Sources	Direct Risks to Production	Weather	Biosecurity
Human	0.655	-0.489	-0.389
Market	0.775	0.135	0.225
Financial	0.823	0.092	0.185
Institutional	0.812	0.119	0.168
Technology	0.826	0.016	0.056
Weather	0.212	0.928	-0.104
Biosecurity	0.282	-0.087	0.909
Factor interpretation (% variance explained)	47.07%	16.46%	13.98%

3.3. Risk Management Strategies Adopted by Farmers

Twelve risk management strategies were constructed based on the most relevant strategies discussed in the reviewed studies. More than a quarter of the studies (28%) found that farmers considered "crop and animal diversification" to be an effective risk management strategy (Table 3). "Pests and diseases monitoring and prevention" was adopted by farmers in 40 studies. "Off-farm work" (14%) and obtaining "farm insurance" (13%) were the third and fourth most frequently stated management strategies. "Cooperation with other farmers", "extension services" and "training and education" were less frequently stated (Table 3).

Table 3. Frequencies of risk management strategies taken by farmers across reviewed literature ($n = 116$). Note, many articles described more than one risk strategy.

Risk Management Strategies	Number	%
Crop and animal diversification	56	28
Pests and diseases monitoring and prevention	40	20
Off-farm work	27	14
Farm insurance	25	13
Off-farm investment	20	10
Debt reduction	19	10
New technology adoption	13	7
Produce at the lowest costs	11	6
Extension services	9	5
Cooperation with other farmers	8	4
Update with government	8	4
Training and education	2	1

Factor analysis of management strategies resulted in three components (factors) explaining 58.87% of the total variance (Table 4). The factor model had a Kaiser Mayer Olkin measure of 0.784, and the Bartlett's Test of Sphericity was significant ($p < 0.001$). In the first component, the risk management strategies with the highest loadings were "crop and animal diversification", "pests and diseases monitoring and prevention", "off-farm work", "farm insurance", "off-farm investment", "debt reduction", "produce at the lowest costs", and "cooperation with other farmers". The first component was labelled as *on-farm and financial strategies*. The second component, *knowledge support*, had high loadings for three variables "extension services", "update with government", and "training and education". The last component, *productivity solutions* included "crop and animal diversification" and "new technology adoption".

Table 4. Results of factor analysis on management strategies used by farmers ($n = 116$) (Varimax rotated; Coefficient values ≥ 0.45 in bold).

Risk Management Strategies	On-Farm and Financial Strategies	Knowledge Support	Productivity Solutions
Pests/diseases monitoring and prevention	0.463	0.178	-0.523
Off-farm work	0.591	0.238	0.245
Farm insurance	0.729	0.143	0.137
Off-farm investment	0.786	0.214	0.016
Debt reduction	0.808	0.028	0.082
Produce at the lowest costs	0.730	-0.019	-0.161
Cooperation with other farmers	0.593	0.007	0.001
Crop and animal diversification	0.615	0.096	0.519
New technology adoption	0.172	0.135	0.752
Update with government	0.105	0.747	0.166
Training and education	-0.089	0.880	0.061
Extension services	0.365	0.672	-0.186
Factor interpretation (% variance explained)	31.75%	16.40%	10.72%

3.4. The Linkage between Perceived Risk Sources and Management

A factor analysis was performed on 93 studies (47%) that explored both risk sources and risk management strategies, resulting in six components explaining 71.32% of the total variance (Table 5). The factor model had a Kaiser Mayer Olkin measure of 0.793, and the Bartlett's Test of Sphericity was significant ($p < 0.001$). The first component, *direct risks and financial strategies*, included six risk sources: "human", "market", "input", "financial", "policy" and "technology"; with four risk management strategies: "farm insurance", "off-farm investment", "debt reduction", and "produce at the lowest costs". The second component, *weather and strategies*, comprised "weather" risk clustered with three management strategies "crop and animal diversification", "off-farm investment", and "off-farm work". The third component, *knowledge support* consisted of three risk management strategies "extension services", "update with government", and "training and education". The fourth component was

named *biosecurity and strategies* as it comprised one risk source, “biosecurity”, and one risk management strategy, “pests and diseases monitoring and prevention”. The fifth and sixth components consist of two risk management strategies, “new technology adoption” and “cooperation with other farmers”, which were named *technical solution* and *external relationship* respectively.

Table 5. Results of factor analysis of studies combining risk perception and risk management ($n = 93$). (Varimax rotated; Coefficient values ≥ 0.45 in bold).

Risk Sources and Risk Management Strategies	Direct Risks and Financial Strategies	Weather and Strategies	External Support	Biosecurity and Strategies	Technical Solution	External Relationship
Human	0.794	−0.048	0.127	0.004	0.019	−0.162
Market	0.682	0.228	0.046	0.318	0.375	−0.019
Financial	0.778	0.135	−0.025	0.180	0.142	0.211
Institutional	0.747	0.246	0.113	0.234	0.071	0.075
Technology	0.808	0.116	0.049	0.087	−0.116	0.205
Debt reduction	0.645	0.435	0.012	−0.049	−0.091	0.317
Produce at the lowest costs	0.679	−0.122	−0.015	0.071	0.003	0.431
Farm insurance	0.478	0.384	0.077	0.269	0.095	0.225
Off-farm investment	0.596	0.461	0.191	0.149	−0.114	0.162
Weather	−0.057	0.703	0.033	−0.210	0.409	0.142
Crop and animal diversification	0.341	0.471	0.011	−0.088	0.433	0.264
Off-farm work	0.281	0.770	0.145	0.240	−0.117	−0.107
Update with government	0.290	0.100	0.777	−0.127	0.106	−0.126
Training and education	−0.097	−0.003	0.899	0.027	0.113	−0.027
Extension services	0.110	0.171	0.653	0.237	−0.158	0.405
Biosecurity	0.181	0.128	−0.033	0.859	0.137	−0.042
Pests and diseases monitoring and prevention	0.293	−0.218	0.113	0.592	−0.341	0.255
New technology adoption	0.033	0.023	0.109	0.055	0.862	0.060
Cooperation with other farmers	0.241	0.117	−0.008	0.029	0.138	0.818
Factor interpretation (% variance explained)	25.53%	11.24%	10.34%	8.28%	8.02%	7.91%

Ten out of the 93 studies (11%) concluded that there was a mismatch between farmers’ perceptions of risks sources and their risk management strategies addressing the risks accordingly. This was confirmed by the results of Spearman’s rank correlation coefficient. This test showed that some of the risk sources were not correlated with risk management strategies. Varying association between risk sources and risk management strategies were found (Table S2). There existed moderate agreements between “technology risk” and “produce at the lowest costs” ($r^2 = 0.65$; p -value 0.01); “institutional risk” and “off-farm investment” ($r^2 = 0.62$; p -value 0.05), “debt reduction” ($r^2 = 0.62$; p -value 0.01), “farm-insurance” ($r^2 = 0.55$, p -value 0.01); “weather risk” and “crop and animal diversification” ($r^2 = -0.42$, p -value 0.01); and “biosecurity threats” and “pests and diseases monitoring and prevention” ($r^2 = 0.31$; p -value 0.01).

3.5. Socio-Economic Factors Affecting Farmers’ Perceptions of Agricultural Risks

Thirty-five studies (18%) mentioned potential socio-economic factors determining farmers’ perceptions of agricultural risks (Table S3). Factors included educational levels, farmers’ age, gender, farm size, experience in farming, farm income, and farm location.

3.6. Socio-Economic Factors Affecting Farmers’ Choices of Risk Management Strategies

Only 21 studies (11%) investigated factors affecting farmers’ adoption of risk management strategies. These studies, collectively, mentioned some factors including educational levels, farm size, experience in farming, farm location, farm ownership, gender, and annual farm income (Table S4).

3.7. Barriers to the Management of Agricultural Risks

Twenty-two out of 197 studies (11%) explored barriers to the management of agricultural risks (Table S5). Lack of information helping farmers control agricultural risks was mentioned in 15 studies, mostly in developing countries. Poor access to formal, low risk, and regulated financing was found

to hinder farmers' ability to manage their farming enterprises, as discussed in 10 studies. Limited institutional support and lack of market mechanisms (access and input supplies) were additional barriers encountered by farmers.

4. Discussion

4.1. Perceptions of Risk Sources

Our systematic literature review of research dealing with farmers' perceptions of agricultural risks and their management yielded 197 studies for detailed analysis. We categorised agricultural risks into seven types based on and combined with the various existing risk categorisations. Agricultural production heavily depends on demand and market price, and market risk was considered the most significant risk [8]. Surprisingly, in this review, market risk was more frequently mentioned than risk relating to weather and climate (55% of articles). Biosecurity threats were the second most frequently perceived risk across the reviewed studies, highlighting the emerging significance of biosecurity threats among all agricultural risks, which is corroborated by the observed increasing importance of biosecurity management [41].

Human risk was mentioned in 35% of the studies, mostly in regard to human health (pesticide usage, some farmers' diseases). This was also expected as farming activities depend on physical labour, particularly in developing countries where humans are a pivotal asset to agricultural production [42]. Of the reviewed studies, 15% reported that farmers increasingly express concern about institutional risk, as changes to government policies can affect the viability and sustainability of farming enterprises [11,12].

The factor analysis identified three main clusters of risks, of which we classify *direct risks to production* as the first category. The second and third categories encompass *weather risk* and *biosecurity threats*. This demonstrates that farmers conceptualise risks associated with biosecurity and weather-related risks, such as climatic change, separately to other identified risk types. One reason why weather risk and biosecurity threats seem to be considered separately might be because farmers treated them as intrinsic features of farming production cycles rather than direct risks such as market risk and financial risk. Based on the intrinsic features of the two risks, if weather risk were grouped with biosecurity threats, it could improve future risk management because farmers with inadequate adaptive capacity are likely to be highly vulnerable to climate risks, especially smallholders or farmers in developing countries [43,44]. For instance, coupling pest and disease distribution predictions with climate predictions could reduce risks more efficiently than if both risks were managed separately.

The risk group of "human", "market", "institutional", "technology", and "financial" are *direct risks to production* and mostly occur as a consequence of farm-level decision-making and actions. Farmers need to gather information and make decisions themselves to manage those risks at the farm level, with decisions varying among farmers. Among the five risks in the group, market risk and institutional risk may be correlated because they are viewed as both expected and, as such, beyond the direct control of farmers. For example, any policy relating to agriculture such as environmental regulations, food safety, or business regulations will affect production [45], but the avenues by which farmers can influence such policy are at the best convoluted and insurmountable at worst.

4.2. Risk Management Strategies

Risk management strategies varied across studies. The most commonly selected strategies were to diversify production sectors to minimise risk [46,47], pursue off-farm work, or purchase insurance [48,49]. In most studies it was found that farmers were not likely to adopt new technologies although adopting innovative practices is pivotal to foster agricultural production sustainably [50] and efficiently [51].

The factor analysis identified that "training and education" and "extension services" correlated with "update with government", which may indicate that training and extension services from relevant

government bodies are generally well received by farmers. Farmers' participation in training has been shown to increase net income and higher yield [52]. Some training programs which were initiated by the government delivered a positive outcome for farmers [53]. The other clusters of risk management strategies are "productivity strategies" and "financial strategies".

4.3. The Linkage between Risk Sources and Risk Management Strategies

Risk perception can affect economic behaviour, and thus the decision to adopt a specific risk management strategy [54]. Many studies have demonstrated that risk perception and risk management strategies are understood and analysed on a case-by-case basis [55–58], so it is essential to explore potential mismatch between risk sources and management and the reasons why farmers select particular strategies over others. The mismatch between perceived risks and risk management strategies was identified by the authors of 11% of 197 studies (10 studies).

The factor analysis found some correlations and patterns between risk sources and risk management strategies. Firstly, the "direct risks and financial incentives" group includes the risks (market, financial, human, institutional, and technology), and those risks are mainly matched with financial strategies (farm insurance, debt reduction, produce at the lowest cost). On the one hand, those strategies were seen as effective in tackling the volatility of output and input prices, and unfavourable changes in the financial market, but were not relevant in tackling "human risk." Secondly, facing weather risk, farmers have a range of strategies to diversify their income (off-farm investment, off-farm work, crop and animal diversification), while when facing biosecurity threats, they tend to rely on only "pests and diseases monitoring and prevention". Maybe the weather has always been an issue, and farmers learned constantly adapt to changes in weather and climate, but biosecurity might be too new, a potential knowledge gap. Thirdly, another cluster of risk management was identified as "knowledge support" which included training, education, extension services, and updates from the government. This suggests the primary role of government in supporting farmers with more training and extension services, as highlighted by Fielke and Bardsley [59]. The two last risk strategies "new technology adoption" and "cooperation with other farmers" were not associated with any risk sources.

"Technology risk" and "new technology adoption" did not load highly on the same factor. Farmers that claimed to experience changes in technology did not consider new technology instalment as a strategy to address that particular risk. Besides, farmers do not appear to adopt new technology as a response to risk. "Technology risk" was clustered with "crop and animal diversification", possibly signifying that farmers used technology to boost productivity [60] rather than to address inherent risk. This could indicate that technology adaptation could be related to a long-term planning rather than being reactive to a specific risk. "Cooperation with other farmers" was not associated with any specific agricultural risks, which may indicate farmers' interaction with other farmers for purposes such as networking and social events, rather than to tackle specific risks.

4.4. Socio-Economic Factors Affecting Farmers' Risk Perceptions and Management of Risks

Few studies have investigated the socioeconomic factors influencing farmers' risk perceptions. Perceptions of risk can differ between male and female farmers [61–63], as female farmers were more concerned about the critical roles of education and extension service in farming [64]. Education has been positively related to personal risk, farm business risk, and off-farm income [61,65–67]. Results show mixed findings between the age of farmers and risk perceptions. In South Africa, older farmers were more worried about the possible shortage of farm labour than younger farmers [61]. According to Borges and Machado [67], however, age did not significantly affect farmers' risk perceptions in Brazil.

Some studies reported that farmers who managed larger farms were primarily concerned with production risks [64,68,69]. The geographic location of farms had a substantial impact on farmers' risk perceptions [2,70,71], for instance, Norwegian farmers in areas with convenient transport tended to pay more attention to production risk than other risks when compared to farmers at more remote locations [11].

Despite weather-related risk and biosecurity threats being frequently mentioned in the 197 studies, factors affecting farmers' perceptions on weather-related risks have been extensively investigated, but factors influencing farmers' biosecurity risk perception have been sparsely studied. Driven and motivated by the trend and impact of climate change on agriculture, weather-related risk has received enormous interest from researchers and farmers alike [72]. Fewer studies (21) focused on the socio-economic factors affecting farmers' risk management strategies. Education levels, farm size, and farmers' experience in farming were found to have a significant impact on how farmers perceive and adopt risk management strategies [27,67,73].

As socio-economic factors play essential roles in risk perception and risk management strategies [18,74], more theoretical and empirical work should be done to explore the potential factors affecting farmers' risk perception and risk management.

4.5. Barriers to the Management of Agricultural Risks

The results of this review reveal a range of barriers to managing agricultural risks. However, most research on barriers to managing agricultural risks has presented results from case studies in large agricultural enterprises in developed economies [75,76] and in small-scale agriculture in developing countries [2,77].

A lack of institutional support from the government was identified as a significant barrier to managing agricultural risks in both developing and developed countries. For example, in Nigeria, Baruwa, Masuku, and Alimi [78] a lack of a lack of marketing training and support from the government for plantain farmers was identified. Similarly, Indian farmers aiming to adopt organic farming practices encountered institutional problems and a lack of support from the government in acquiring new methods to control pests and diseases and accessing new markets [79]. The need for better institutional support from developed countries has been confirmed [17].

Poor and smallholder farmers are particularly vulnerable to agricultural risks [2,80] and have difficulty adopting new technologies and crop types due to inadequate technical knowledge, lack of funds, and limitations to their production technology [81]. Financial and technical support from reliable sources is often inadequate [29,78]. For instance, smallholder farmers in Ethiopia, Madagascar, and Pakistan have reported failure in accessing formal financial services [29,58,64].

5. Research Gaps, Implications and Limitations

This review has revealed a number of research gaps. Firstly, there is an apparent discrepancy between the frequency that risks are mentioned by farmers and the volume of research on socio-economic factors that explain the perception of risks. For example, despite biosecurity being the second most cited risk, there is very little knowledge on the factors driving biosecurity risk perception. In addition, no studies identified in the review covered both developing countries and developed countries, highlighting the opportunity for studies that explore risk across large gradients of development. The paucity of studies on education was highlighted, which points out the need for available training and extension services for farmers. This is most likely because the studies were not published in refereed journals and the number of articles may increase by expanding this review to unpublished literature.

Moreover, there is a need to understand why there is a mismatch between farmers' perceived agricultural risk sources and risk management strategies. A better understanding of why management strategies that appear to be a suitable response to particular risks are not employed might highlight further barriers to agricultural risk management, which, if overcome, could enhance the productivity of agricultural systems. Finally, surprisingly few studies take a comprehensive view of the factors that determine farmers' risk perceptions (18%) and their risk management strategies (11%).

The clusters of risk sources described in this review could be used as a basis for further research exploring why risks cluster, why farmers perceive certain risks as more threatening than others, and how this clustering affects farmers' management strategies. Finally, addressing the knowledge gap

on socio-economic contextual factors that influence farmers' risk perceptions and decisions about management strategies could enable government programs to better target farmers who are more likely to be amenable to particular programs.

While unlikely to have influenced the conclusions, there were some limitations to this study. Firstly, grey literature was not included, limiting the sample size and diversity. We have no reason to believe, however, that the grey literature would have differed markedly from peer review literature in terms of scope and subject matter. Secondly, the analysis in this review was conducted at the article level, so it did not include details that might have emerged from the raw data, including farmer-level data, across the reviewed studies. Research is therefore required to capture the full diversity of farmers' opinions and their perceptions of specific risk sources and risk management strategies.

6. Conclusions

Risks associated with agriculture are increasingly diverse, complex, and interconnected. Consequently, there is a pressing need to gain a greater understanding of the nexus of agricultural risks, how farmers respond to risk, factors affecting their perceptions and management of risk, and barriers hindering the way they manage risks to ensure stable livelihoods and global food security. Here, we have reviewed the literature within this intellectual space, shedding light on what is known and what still needs to be known. We also revealed some interesting anomalies and points of interest including the absence of studies across large developmental gradients, the small disproportionality volume of research on biosecurity risk management strategies and socioeconomic factors associated with biosecurity threats, the apparent mismatch between perceived risks and management responses, and the clustering of risks and risk management strategies. A better understanding of farmers' risk perceptions and risk management strategies, factors affecting their perceptions and management, and the barriers to their risk management could enable more collaborative solutions to managing future risks.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2077-0472/9/1/10/s1>. Table S1: List of 197 studies included in the review, Table S2: Spearman tests between market risks and risk management strategies, Table S3: Socio-economic factors affecting farmers' perception of agricultural risk sources ($n = 35$), Table S4: Socio-economic factors affecting farmers' perception of agricultural risk management strategies ($n = 21$), Table S5: Barriers affecting farmers' management of agricultural risk sources ($n = 22$).

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