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RISK FACTORS AND PROTECTION STRATEGIES IN SMALL AGRICULTURAL PRODUCTION UNITS IN THE STATES OF TABASCO, GUERRERO, AND CHIAPAS, MEXICO

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ABSTRACT

There are currently multiple risks in Mexico's agricultural sector, so it is critical to have concise and accurate information on the main mitigating factors faced by producers in order to contribute to the creation of risk management instruments that meet their needs. In this work, the unit of analysis was established on the basis of a census of 6852 small farmers (those with less than five hectares of sown area). Using a stratified sampling of 317 producers in the states of Tabasco, Guerrero, and Chiapas, risk management was analyzed in their production units. The sampling, with a precision level of 5 % and a reliability of 95 %, allowed obtaining representative results for the target population. Through a descriptive analysis, the profile of the producers was identified, detecting the main risks they face and the strategies they use to mitigate them. Frequency graphs were used to visualize the distribution of the variables analyzed. To evaluate the relationship between risk management and risk perception, chi-square and Cramér's V contingency tests were applied. This study revealed a statistically significant relationship among 9 out of 13 risks analyzed and the risk management. In only six cases, the strength of association is moderate. This suggests that different tools exist to mitigate various hazards (natural disasters, pests and diseases, input prices, etc.), but their effectiveness varies by type. In the face of an adverse situation, producers often resort to strategies such as reducing food at home, using savings, and relying on government support. This study provides specific data on the specific conditions and challenges of these regions, enriching the general knowledge on family farming in Mexico.

Keywords: management, risk, perception, farmers.

INTRODUCTION

Agriculture is a business with a high level of risk since all activities related to the production of any type of crop involve a high degree of uncertainty. Structural

adjustments in economic matters, trade changes, and climatic anomalies, among other factors, affect producers directly or indirectly (Calatayud and Ketterer, 2016; Spiegel *et al*., 2021). In order to cope with all these risks, reduce vulnerability, and increase resilience, farmers tend to implement two risk management strategies: the ex-ante strategies that are used to reduce risk and mitigate any potential loss caused by any adverse factor to the production unit, and the ex-post coping strategies that are applied after suffering a loss as a result of a specific risk (Musyoki *et al.*, 2022).

Currently, policy makers have a strong interest in ensuring investments that encourage the implementation of actions capable of contributing to the generation of resilience, with the goal of making them more effective and targeted, particularly to the sectors that require them the most. Robust resilience measurement can make valuable contributions by identifying hotspots, understanding drivers, and inferring impact (Jones and d'Errico, 2019).

Producers' adaptation measures from the short to the long term are not limited to the resources available for agricultural production but also to how they understand and perceive the various risks, such as systemic risks (changes in government, product price, farm support, labor availability, and the presence of hydrometeorological phenomena), operational (soil fertility, bank credits or loans, and presence of diseases or pests), market (requirements for the sale of products, availability, and price of agricultural inputs), and the risk related to the life of the producers, such as health (Goodwin and Ker, 2002; Hardaker *et al*., 2015; Spiegel *et al*., 2021; Tapia-Díaz, 2006).

The uncertainty associated with these aspects can influence decision-making (Etongo *et al*., 2022) and, consequently, the risk management strategies that producers apply. The identification and perception of these risks are a key step for the development of effective and innovative management strategies. These strategies can range from the creation of public policies that generate certainty in agricultural activity to the modification of existing policies with a focus on protection, support, and consolidation of the various existing production units.

In the Mexican context, the problem of agricultural risks is more acute in the case of small producers, who represent a significant percentage of the sector and face specific conditions of vulnerability. Specifically, in the study area comprising the states of Guerrero, Chiapas, and Tabasco, these risks are intensified due to the prevalence of subsistence agriculture, the high dependence on staple crops such as corn (*Zea mays* L.) and beans (*Phaseolus vulgaris* L.), the limited productive infrastructure, and the presence of recurrent meteorological phenomena (CENAPRED, 2022; SIAP, 2023).

The situation is aggravated by the high degree of land fractionation in the region. According to the National Agricultural Census (INEGI, 2023), there are 4 629 134 active agricultural production units in Mexico. The states of Guerrero, Chiapas, and Tabasco account for 19.8 % of these units, but only 12.1 % of the planted area, resulting in a smaller scale of production (2.9 ha) compared to the national average (4.7 ha). In addition, these states present high poverty rates, exceeding 50 % of the population in each of them (CONEVAL, 2020a).

This study seeks to analyze the risk factors and protection strategies implemented by small producers in the aforementioned states in order to generate knowledge that may contribute to the design of public policies that promote their resilience and improve their living conditions. This study provides theoretical information on risk, resilience, aversion, types of risks and their sources, as well as the forms of risk management in small agricultural production units, in order to better understand the conditions and ways in which producers face the difficulties that may arise within their units.

MATERIALS AND METHODS

A survey was designed to analyze the different types of risk that a small farmer may suffer in the states of Tabasco, Guerrero, and Chiapas, Mexico. The approach is of mixed type, which implies a set of processes for collecting, analyzing, and linking quantitative and qualitative data in the same study, with the goal of solving the research problem (Sampieri *et al*., 2014).

Delimitation of the analysis unit

The unit of analysis was established based on the census of 6852 small producers registered in the ProBienestar program in the states of Tabasco (municipalities of Centla and Tenosique), Guerrero (municipalities of Cuajinicuilapa and Zapotitlán Tablas), and Chiapas (municipalities of Chiapilla and Nicolás Ruíz). According to the National Council for the Evaluation of Social Development Policy (CONEVAL, 2020b), the rural population of the selected municipalities presents high percentages of poverty. The municipality of Zapotitlán Tablas in the state of Guerrero has the highest poverty rate and is classified as very highly marginalized, according to the National Population Council (CONAPO, 2020). The main existent crop is rainfed corn (Table 1).

Table 1. Characteristics of the analysis unit by state and municipality (CONAPO, 2020; CONEVAL, 2020b).

State	Municipality	Rural population*	Rural population in poverty (%)*	Farmers**	Degree of marginalization*
Chiapas	Chiapilla	3128	83.13	282	High
	Nicolás Ruíz	n.d.	n.d.	503	High
Guerrero	Cuajinicuilapa	13 073	53.37	665	High
	Zapotitlán Tablas	12 414	91.37	3256	Very high
Tabasco	Centla	95 916	80.77	1025	Medium
	Tenosique	26 384	66.81	1121	Low

*Year 2020 information; **year 2021 information. n.a.: not available.

Sample determination and data collection

The sample size was determined using stratified sampling methodology with a precision of 5 % and reliability of 95 %. The producers' planting area was used as

a stratification variable. This produced a base of 317 small producers distributed in three states and six municipalities: Chiapas: Chiapilla (n = 13) and Nicolás Ruíz (n = 23); Guerrero: Cuajinicuilapa (n = 31) and Zapotitlán Tablas (n = 151); and Tabasco: Centla (n = 47) and Tenosique (n = 52).

The information was collected through face-to-face surveys with randomly selected farmers from April 11 to June 30, 2022. The surveys were conducted after the pilot test information sessions at the Parametric Insurance Program for Small Corn Producers, implemented by AXA Climate, Guy Carpenter, Munich Re, Raincoat, and Swiss, in collaboration with the Ministry of Agriculture and Rural Development and AGROASEMEX. Producers who attended the different sessions were identified, randomly selected, and asked whether or not they could answer a simple questionnaire related to risk management in their production unit (translated in a more understandable way to producers as a questionnaire of problems that may affect them in their plot). The questionnaire consisted of four sections.

The first section of the survey analyzed the producer's profile (age, gender, and schooling); the second focused on characterizing the production unit (seniority within the activity, main crop, area planted, and number of members employed in the production unit); the third analyzed the main risk management strategies in their production unit (sale of animals, land, crop change, adjustment of planting dates, government support, etc.); and finally, the fourth section consisted of the different sources of risk and their perception of them (price of agricultural inputs, credit or bank loans, soil fertility, insecurity, etc.).

The first two sections included "open-ended" questions, and the third section presented dichotomous (yes and no) responses. The items comprising the risk perception section consisted of a series of Likert-type questions ("not at all challenging," "not very challenging," "slightly challenging," "neutral," "moderately challenging," "very challenging," and "extremely challenging").

Information analysis

The data on the producer's profile and the characteristics of the production unit were analyzed to obtain descriptive statistics (mean, standard deviation, maximum, minimum). The risk factors were analyzed by summing the individual values of the responses according to each item (absolute value on the Likert scale) and finally expressing them in percentages. The risk management strategies mentioned by the producers were coded using a binary system (Yes = 1, No = 0). Then, the frequency of each strategy was calculated, i.e., the number of producers who mentioned at least one or more options.

For the study of the association between risk perception and risk mitigation strategies, the chi-square test of independence was used, which compares the sample results with the expected results if the null hypothesis is true. The conclusion of the hypothesis test is based on how "close" the sample results are to the expected results (Anderson *et al*., 2008). The null and alternative hypotheses required to be tested were:

Null hypothesis (H_0) = Producers' perception of risk sources is not related to the risk management strategies they adopt.
Alternative hypothesis (H_1) = Producers' perception of sources of risk is related to the risk management strategies they adopt.
The following formula for chi-square was used:

$$x^2 = \sum_{i=1}^{R} \sum_{j=1}^{C} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where x^2 is the chi-square statistic and O_{ij} is the frequency of the observed value of k number of categories. In order to simplify the analysis and obtain clearer conclusions, the number of risk perception categories was reduced from seven to three. For this purpose, the values obtained in each of the seven original categories were summed, and the results were reclassified into the following groups: a) the producer sees the different types of risks as challenging, b) the producer recognizes that challenging risk conditions exist, and c) the producer sees the different types of risks as very challenging. For the frequency of the expected value, $E_{ij} = \frac{R_i C_j}{n}$, R_j is the total number of rows, C_j is the total number of columns, and n is the total sample size.

Under the critical value method, the significance level was 5 %, $x^2 = x^2_{0.05}$ with (i - 1) (j - 1) degrees of freedom. Therefore, the null hypothesis is rejected when:

$$x^2 \geq x^2_{0.05}$$

If the chi-square results determine that there is an association between risk perception and the strategies implemented by producers, the index of association between variables will be measured. For this, the V of Cramér coefficient was used, which takes the value of one when there is a perfect association between attributes (risk perception and strategies), whatever the number of rows and columns in the contingency table analyzed (Shah and Alharthi, 2022). The strength of the association varies according to the value of V: it is weak if V < 0.2, moderate if 0.2 < V < 0.6, and strong if V > 0.6. The V of Cramér formula is:

$$V = \sqrt{\frac{x^2}{N(k-1)}}$$

where V is Cramér's V statistic, x^2 is the chi-square statistic, N is the total number of observations, and k is the minimum between the number of rows and columns.

Data were analyzed using the SPSS 24.0 software (IBM Statistics, Chicago, IL, USA).

RESULTS AND DISCUSSION

Socioeconomic profile

The survey covered 317 producers, of whom 32 % (111 producers) are women and 68 % (232 producers) are men. This composition reflects the participation of women in agriculture, which is significant in this sector, although there are still gender gaps. Regarding age and farming experience, the descriptive statistical analysis revealed a remarkable variability. Producers present different ages and therefore different degrees of experience within the agricultural activity. This diversity is an important aspect to consider when designing and evaluating public policies and support programs aimed at this sector. In contrast, the characteristics of the production units did not show significant variation (Table 2). This suggests that, in general, producers share similar conditions in terms of the size of their plots, the crops they produce, and the resources available.

Table 2. Characteristics of the small-producer population analyzed in the states of Tabasco, Guerrero, and Chiapas, Mexico.

Variables	Mean	SD	Minimum	Maximum
Age	49.52	15.35	18	95
Last degree of study	6.73	3.93	0	18
Agricultural experience	24.66	15.53	1	70
Area planted (hectares)	2.71	1.29	1	9
Family members	4.65	1.99	1	12

Risk factors

Agricultural activities are exposed to a wide variety of risk factors (Figure 1), which may or may not generate negative impacts on producers. Understanding these risks and the degree of challenge they pose for producers is essential to develop tools that provide certainty at all stages of agricultural production.

According to the data, hydrometeorological phenomena are the primary risks that producers face in their production units (Shah and Alharthi, 2022). According to the National Agricultural Survey (INEGI, 2017, 2019), a high percentage of producers reported crop or animal losses due to climatic events such as droughts (74.7 % in 2017 and 85.3 % in 2019), excess humidity, floods, and frost, among others, which coincides with what was reported by Tapia-Díaz (2006). This climate variability can trigger the development and spread of weeds, pests, and diseases, altering the balance in agroecosystems (FAO, 2024).

Therefore, understanding climate risks and vulnerabilities is fundamental to implementing more resilient production practices (Etongo *et al*., 2022). Failure to do so increases the risk of relying on the intensive use of agrochemicals, which can generate negative impacts on the environment and raise production costs.

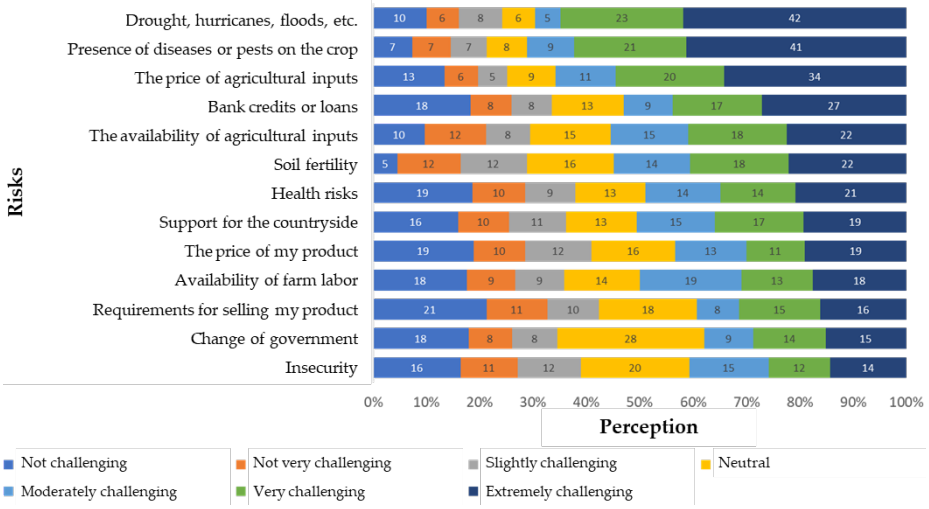

Figure 1. Perception of the different types of risk faced by producers in their production units in the states of Tabasco, Guerrero, and Chiapas, Mexico, using a Likert-type scale.

Strategies for risk

Facing any type of risk entails the implementation of various strategies and approaches, ranging from seeking or receiving direct support from government institutions to considering options such as selling assets or applying for credit. In order to better interpret the results, the different strategies were classified into four main groups: a) support strategies contracted by the producer, b) support strategies external to the producer, c) support strategies not foreseen by the producer, and d) support strategies involving the management of the production unit.

Ex-post strategies, such as those not foreseen by the producer, have a greater weight compared to the other strategies (Figure 2). This would indicate that the producer,

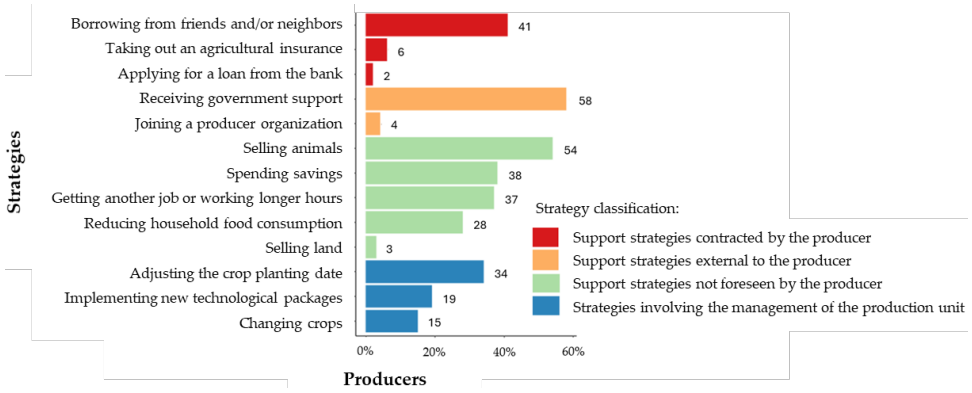

Figure 2. Strategies adopted by producers in the face of different types of risk in the states of Tabasco, Guerrero, and Chiapas, Mexico.

faced with a risk situation in his production unit, prefers, for example, to dispose of his current fixed assets or use his savings, which in the short term would mean the decapitalization of the producer. Support strategies not contracted by producers tend to be the least attractive options.

A crucial aspect that emerged from the survey was the direct opinion of the producers on government support. Although they pointed out that this support was of great help, they also stated that it was insufficient since it allowed them to return to their productive activities, but they could not recover all the investment generated in the management of the crop at the time of the loss. This is why they are considered in this research as secondary management options for external support to the producer.

Association between risk perception and risk mitigation strategies

Humans perceive risk and act upon it in two ways. The first is based on emotions, reflecting the instinctive and intuitive reactions of individuals to danger such as fear or anxiety that drive them to seek refuge (Slovic and Peters, 2006). The second is based on logical and reasoned analysis for the management of different types of risk. In their study, Wachinger *et al*. (2013) suggest that high risk perception may motivate producers to take personal protective measures. However, this possibility depends on various factors.

First, memory of past events and the ability to imagine the potential effects of a natural disaster are crucial to risk perception. If producers have not directly experienced a disaster or cannot visualize its consequences, they are less likely to take preventive measures. In addition, confidence in the receipt of government support can create a dynamic in which farmers are disincentivized to take precautions in the face of impending risks. If they perceive that the government will cover their losses, the need to invest in protective measures or modify their farming practices to minimize risk becomes less pressing (González-Estrada and Orrantia-Bustos, 2006). This situation can result in lower productivity and competitiveness for the sector. Furthermore, not all of the strategies that producers can take coincide with their perception of them (Table 3).

Since the X^2 calculated for the variables of contracting agricultural insurance, receiving government support, selling animals, spending savings, getting another job or working more hours, reducing household food consumption, adjusting planting dates, implementing new technological packages, and changing crops is greater or equal in at least one of the four risk categories with a significance of $X^2_{0.05} = 5.99$, it is inferred that there is a significant difference between the expected values under the null hypothesis and the observed values. Consequently, producers' perception of the different types of risk related to their production unit is associated with their choice to adopt any of the nine risk management strategies (Osiemo *et al*., 2021). The use of strategies such as applying for loans, accessing credit, joining organizations, or selling their land was not considered by producers as a viable management option. However, despite this perception, these alternatives should not be less important.

Table 3. Chi-square tests for the relationship between strategies against risks and different types of risk perceived by small producers in the states of Tabasco, Guerrero, and Chiapas, Mexico.

Strategy	Risks			
	Systemic	Market	Operatives	Producer
Borrowing from friends and/or neighbors	4.88	3.62	3.32	4.52
Taking out agricultural insurance	10.80*	8.62*	3.78	12.57*
Applying for a loan from the bank	1.14	1.61	1.88	3.49
Receiving government support	13.96*	19.17*	14.60*	0.22
Joining a producer organization	2.45	1.83	4.15	4.38
Selling animals	6.30*	8.28*	6.59*	2.65
Spending savings	24.78*	20.92*	6.97*	6.50*
Getting another job or working longer hours	5.13	21.39*	10.42*	1.85
Reducing food consumption at home	22.85*	35.53*	23.95*	23.44*
Selling land	2.20	1.12	0.79	1.04
Adjusting the crop planting date	2.26	6.36*	2.53	14.93*
Implementing new technological packages	10.61*	13.44*	10.87*	19.35*
Changing crops	0.01	6.35*	2.91	1.54

*$x^2 \geq x^2_{0.05}$ significant.

The association index between the perception of different types of risk and their decisions to opt for a risk management strategy (Table 4) is moderate ($0.2 < V < 0.6$) for six of the nine risk management strategies. The absence of a strong association may be due to the socioeconomic characteristics of the farmers analyzed and the alternatives

Table 4. Association between risk perception and mitigation strategies in the states of Tabasco, Guerrero, and Chiapas, Mexico, with Cramér's V.

Strategy	Risks			
	Sistemic	Market	Operatives	Farmer
Borrowing from friends and/or neighbors	0.122	0.105	0.100	0.117
Taking out agricultural insurance	0.181	0.162	0.107	0.195
Applying for a loan from the bank	0.059	0.070	0.075	0.103
Receiving government support	0.206	0.241	0.210	0.026
Joining a producer organization	0.086	0.074	0.112	0.115
Selling animals	0.138	0.158	0.141	0.090
Spending savings	0.274	0.252	0.145	0.140
Getting another job or working longer hours	0.125	0.255	0.178	0.075
Reducing food consumption at home	0.263	0.328	0.269	0.267
Selling land	0.082	0.058	0.049	0.056
Adjusting the crop planting date	0.083	0.139	0.088	0.213
Implementing new technological packages	0.179	0.202	0.182	0.242
Changing crops	0.007	0.139	0.094	0.068

they may or may not apply in their production unit (Shah and Alharthi, 2022b). Smallholders choose various alternatives to cope with the risks and challenges they face in their farming activity. These decisions are influenced by their risk aversion, their perception of uncertainty, and their search for strategies to ensure the economic and food security of their families.

Austerity measures such as reducing household food consumption to conserve resources and face the financial crisis, together with the use of previously accumulated savings, which can serve as a financial cushion in times of scarcity or production losses, as well as the search for employment outside the production unit to supplement monthly income, are risk management strategies not foreseen by the producer. Government programs such as subsidies, technical assistance, or subsidized agricultural insurance can be a source of support for small producers in times of difficulty. These public policies are aligned with the National Development Plan (PND), published in the Official Gazette of the Federation on July 12, 2019 (DOF, 2019), which establishes that the main objective is to achieve the well-being of the population. Likewise, it establishes three general axes: I. policy and government, II. social policy, and III. economy. The final axis mentions a strategy of food self-sufficiency and countryside rescue in order to achieve this in basic foods consumed by the population, as well as most of the inputs, machinery, equipment, and fuel for agriculture with the consideration for sustainability, equity, welfare, and respect for the rights of *ejidatarios*, commoners, small landowners, and indigenous peoples.

A notable example is the Production for Well-Being program, whose objective is to channel productive support per hectare prior to planting. This program promotes the adoption of agroecological and sustainable practices, soil, water, and agrodiversity conservation. Another important initiative is the Fertilizers for Well-being program, whose objective is to contribute to the production of priority crops through the delivery of fertilizers to producers throughout the country. This program seeks to ensure the availability of essential inputs for agricultural production, especially for small producers who face difficulties in accessing these inputs on the market.

In addition to programs focused on production and sustainability, the Mexican government has also implemented specific programs to address natural disasters. A historical example was the Agricultural Disaster Assistance Component of the Ministry of Agriculture, Livestock, Fisheries, and Food (SAGARPA), which aimed to support small producers who did not have insurance to protect themselves in case of catastrophic natural events through the delivery of ex-post financial support (Cabestany-Noriega *et al*., 2013). The second program was the Agricultural Insurance Premium Subsidy program granted by the Ministry of Finance and Public Credit (SHCP) and operated by AGROASEMEX, which supported agricultural insurance funds with a percentage of the payment of the insurance premium contracted by producers. Both programs, implemented until 2019 and 2020, respectively, were two of the best-executed producer support strategies by the Mexican government and have even been replicated by other countries.

Finally, the strategies that producers opt for directly within their production unit include the change in crop planting date and the implementation of new technological packages. These have been some of the options that go hand in hand with the implementation of programs and public policies that help generate greater certainty for producers.

CONCLUSIONS

The risk perception of small-scale producers directly influences the selection of adaptation strategies. The results indicate that, in the face of risk, producers especially value government support. Likewise, the importance given to savings strategies and the search for additional income is evidence of the precariousness of their economic conditions and the need to diversify their sources of income. In addition, it became evident that the reduction of household food consumption plays a crucial role in adapting to adverse conditions. Similarly, adjustments in agricultural practices, such as changing planting dates and adopting new technologies, demonstrate a willingness to innovate and adapt to the new climatic conditions.

These findings highlight the importance of designing interventions that address both the immediate needs of producers (such as economic support services, although necessary, should promote producers' independence and avoid creating dependency) and their long-term adaptive capacities (encouraging the adoption of new technologies). These short- and long-term interventions identified in this study seek to strengthen the resilience of producers in the face of adverse conditions.

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