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FUNDAMENTAL TRENDS OF RURAL MUSHROOM CULTIVATION IN MEXICO, AND THEIR SIGNIFICANCE FOR RURAL DEVELOPMENT

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ABSTRACT

The rural production of edible mushrooms (*Pleurotus*) started during 1989 in central Mexico. This activity soon became important as considerable governmental funds were made available to peasant communities. However, the development and significance of mushroom cultivation within the rural household system (RHS) in different regions have not yet been assessed. We developed a model to study the fundamental trends of mushroom cultivation within the RHS in two contrastive regions: 1) Cuetzalan, Puebla; and 2) Toluca, Mexico. Both regions were characterized environmentally and socio-economically. Structured surveys were applied to a random sample (20%: 89) of members from a cooperative in Cuetzalan, while to all peasant mushroom growers (27) in Toluca. RHSs were studied following the systems methodology. Data were statistically analyzed by the correlation of variables studied. Mushroom biotechnology can be adopted and adapted to the RHS needs, keeping a proper balance with other agricultural and extra-agricultural activities. Mushroom cultivation can provide incomes, labour opportunities, and food to the RHS. Three types of RHSs were defined on the basis of the level of integration of mushroom cultivation within the RHS: 1) Constant grower (CG), 2) Frequent grower (FG), and 3) Occasional grower (OG). According to this typology, three regions can be identified for RHSs located around the main urban centres of mushroom consumption: 1) Near the market, 2) Intermediate distance from the market, and 3) Far from the market. It was established that fundamental trends of rural mushroom cultivation are directly associated to main mushroom markets. Accordingly, those RHSs operating as CGs are normally located near the market, FGs are at an intermediate distance from the market, and OGs are far from the market. Depending on this location, RHSs take advantage differentially from the social, economic, and ecological aspects of mushroom cultivation.

Key words: Edible mushrooms, mushroom cultivation, rural household system, rural development, sustainable development, Mexico.

INTRODUCTION

Globalisation is evolving swiftly worldwide affecting economic markets, technologies, and communication patterns. In this context, sustainable rural development in Mexico still remains as a challenge for the XXI century. Social, economic, and ecological conditions are highly heterogeneous all over the country. Urban areas have managed to develop good infrastructure and services for promoting strong investments in industrial development. By contrast, most rural areas are characterized by lower living standards, high emigration rates, high proportions of women and old peasants, strong decapitalization, low levels of food production, and environmental degradation. The contribution of the primary sector to the whole economy is only of about 7% from the gross national product (OECD, 1997).

Several private commercial enterprises have gradually established since 1933 in Mexico, reaching nowadays a total mushroom production in excess of 28,000 tonnes per year (Martínez-Carrera, 2000). Later, the rural production on a small scale started during 1989 and, at present, edible mushrooms (mainly *Pleurotus*) are cultivated and marketed to differing extents in many communities from the central part of

the country (Martínez-Carrera et al., 1991). This activity soon became popular as considerable funds were made available to peasant communities through governmental programmes. However, many of these actions were not followed by suitable and integrated training, technical assistance, spawn availability, a thorough analysis of the local and regional markets, and further financial support. The impact of mushroom cultivation on peasant communities, and its potential for rural development have not yet been evaluated. We have developed a model, the rural household system (RHS), which is used to assess the potential, development, significance, and fundamental trends of mushroom cultivation in two representative regions from rural Mexico.

METHODOLOGY

Regions of study

Rural communities from the States of Puebla and Mexico, where mushroom cultivation is being carried out at different levels, were studied. The main social, economic, and ecological characteristics of regions studied are shown in Table 1. Eight communities (4 Municipalities) from the State of Puebla organized in a cooperative are located in a mountainous region, showing a subtropical climate, high precipitation, and poor levels of communication infrastructure and services. They have a traditional rural diet based on maize, beans, chilli, and coffee. Main community activities are: 1) Commercial production of coffee and pepper; 2) Subsistence agriculture (maize, beans), and fruit crops (orange, mammee, banana); 3) Livestock (fowls, turkeys, hogs); 4) Labouring (mainly agriculture); and 5) Trading. By contrast, 22 communities from the State of Mexico (13 Municipalities) are located within a suburban and densely populated area, showing temperate climate, regular precipitation, good levels of communication infrastructure and services. They normally have a diverse suburban diet. Main community activities are: 1) Labouring (building, services, industry); 2) Trading; 3) Agriculture (maize, oat, wheat, barley, beans); and 4) Livestock (cows, hogs, lambs, fowls, turkeys).

Table 1. Social, economic, and ecological characteristics from the regions studied (INEGI 1999, 2000).

Main characteristics		Region of study	
		Cuetzalan, State of Puebla	Toluca, State of Mexico
Social	Municipality	4 (Cuetzalan, Jonotla, Zoquiapan, Tuzamapan)	13 (Toluca, Jocotitlán, Zinacantepec, Jiquipilco, Ixtlahuaca, Almoloya de Juárez, Tenango del Valle, Villa Nicolás Romero, San Miguel Balderas, Otzolotepec, Metepec, Chapultepec)
	Population	75,697	1,469,177
	Rural mushroom growers	1 (cooperative)	27 (household level)
	Language	Spanish, Nahuatl, Totonac	Spanish, Otomi, Nahuatl
	Organization	Cooperative	Association
	Diet	Maize, beans, chilli, coffee	Diverse suburban
	Main land tenure	Private property (0.25-1.5 ha)	Private property (5 ha)
Economic	Main agricultural activity	Coffee, maize, beans	Maize, oat, wheat, barley, beans
	Communication infrastructure	Poor	Good
	Services (water, electricity, sewerage)	Poor	Good

Ecological	Elevation	300-1,300 m	2,300-2,700 m
	Latitude; longitude	19 °56' north, 29 °11' south; 97°23' east, 97 °37' west	20°17' north, 18°22' south; 98°36' east, 100°37'west
	Mean temperature	18 °C	13.5 °C
	Precipitation	2,250 mm/year	734 mm/year
	Climate	Warm subhumid (Acf)	Broad temperate subhumid (Cw-Cew)
	Vegetation	Moist montane forest	Coniferous forest

The model of analysis

A fundamental model, the rural household system (RHS), based on the systems methodology was used to understand relationships between variables and elements studied (Fig. 1). This model contains four main systems (global, regional, community, rural household) and three dimensions (social, economic, ecological), which are all interrelated considering their sustainability over time.

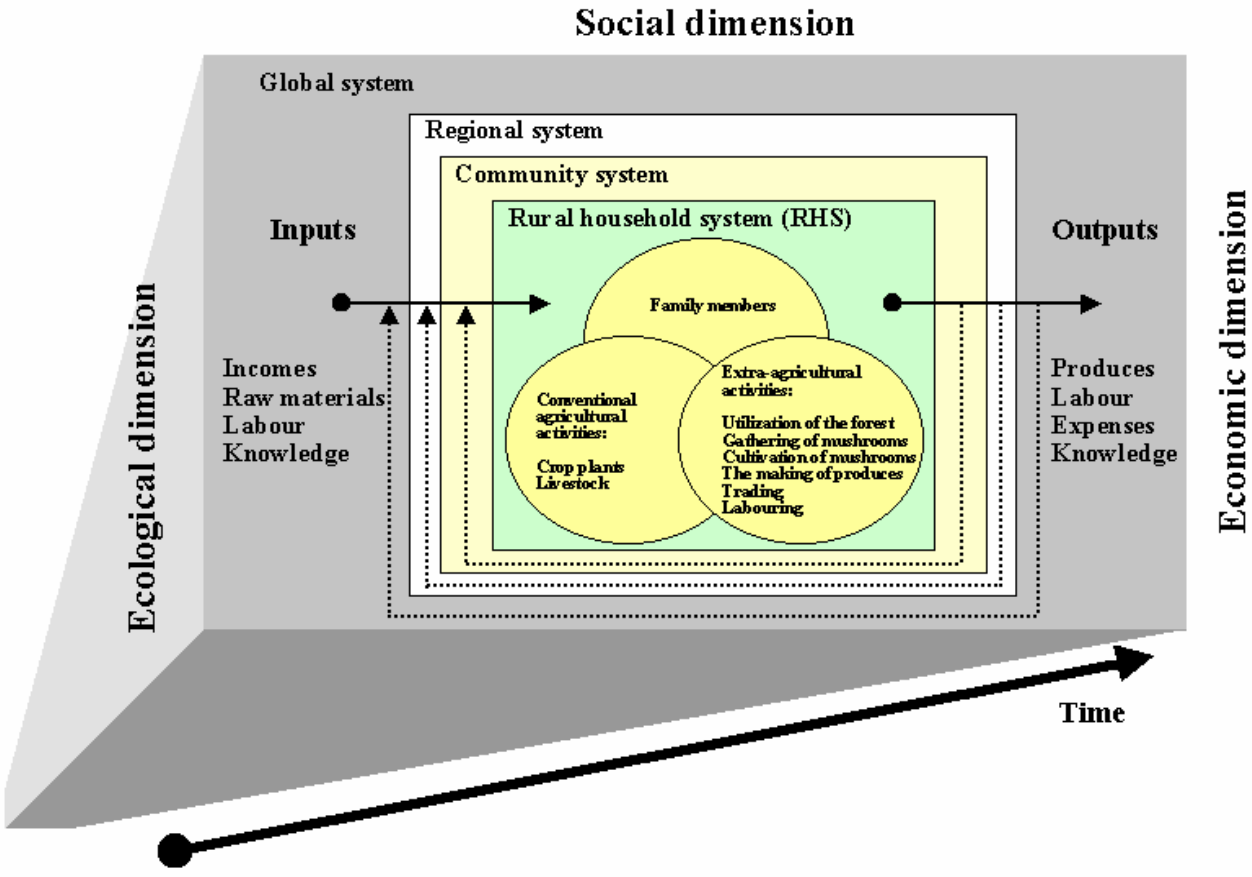

Fig. 1. The rural household system (RHS) model used in this study to assess the potential, development, and significance of rural mushroom cultivation.

The rural household system (RHS) and its study

Rural communities related to primary activities in Mexico are normally represented by diverse household units and their affairs. In this study, we consider such unit as a system, the rural household system (RHS), integrated by three main elements: 1) Family members (organization, life circumstances); 2) Conventional agricultural activities (crop plants, livestock); and 3) Extra-agricultural activities (utilization of the forest, gathering of wild edible mushrooms, mushroom cultivation, the making of produces, trading, labouring). All activities performed within the system generate inputs (incomes, raw materials, labour, knowledge) and outputs (produces, labour, expenses, knowledge), which keep the RHS sustainable. These interrelated elements were studied in order to understand the potential, significance, and main trends of the cultivation, consumption and marketing of edible mushrooms in communities studied. Structured surveys were carried out in RHSs containing the following elements: 1) Characteristics and life circumstances from nuclear family members; 2) Crop plants; 3) Livestock; 4) Utilization of the forest; 5) Gathering; 6) Cultivation of mushrooms; 7) The making of produces; 8) Trading; and 9) Labouring. An interview protocol was developed having variables studied within open-ended, and short-answer open-ended items, as well items with adjectival and adverb responses. Appropriate measurement scales were assigned to each variable. The interview protocol was applied individually by formal interviews, followed by an observation protocol. The region of Cuetzalan was studied by probability sampling, selecting 20% of members (RHSs: 89) from a cooperative by simple random sampling who represented eight communities. This cooperative operates a central mushroom farm where only several members work, and it has been previously assessed (Martínez-Carrera et al., 1998). The region of Toluca was studied interviewing all RHSs (27) growing edible mushrooms belonging to 22 communities. Data were statistically analyzed by the correlation of variables studied using the Coefficient of Pearson (Rojas, 1991).

RESULTS AND DISCUSSION

1) Family members

Characteristics and life circumstances from the RHSs in the regions studied are shown in Table 2. In general, the RHSs from Toluca, Mexico, have developed mushroom cultivation and marketing independently from the wide ranges of age, level of studies, and the proportion of children labouring (age: > 18 years). A high proportion of these RHSs had good type of houses and services. Although the RHSs from Cuetzalan, Puebla, had a lower level of studies and a higher number of children labouring (age: > 18 years), they could have a good potential to become mushroom growers if supported by the central mushroom farm from the cooperative. In this case, technology transfer programmes have to consider the high proportion of RHSs speaking native languages in this region.

Table 2. Comparison of nuclear family members and their life circumstances within the rural household system (RHS) from the regions studied.

Characteristic		Region			
		Cuetzalan (RHSs= 89[a]) 1998-1999		Toluca (RHSs= 27[b]) 1999-2000	
		Range	Average	Range	Average
Native language-speaking people (%)		87		19	
Age (years)	Husband	24-75	45.4	26-63	40.8
	Wife	20-73	40	23-60	36.6
Level of studies (years)	Husband	1-12	3.4	2-17	11.2
	Wife	1-9	3.4	1-17	8.5
Number of children	Total	1-10	4.5	1-5	2.6

	Age	1-37	11.9	2-35	10.7
	Level of studies	1-11	4.6	1-13	5.3
	Labouring	48% (1-4)	1.7	15% (1-3)	2
Type of house	Number of rooms	1-5	2.1	1-10	5.1
	Building materials	Mud-bricks, wood, waterproof cardboard, pantile (62%); bricks and pantile (38%)		Bricks, roof of concrete (44%) or asbestos (56%)	
	Services	Water (61%), electricity (58%), sewerage (7%)		Water (96%), electricity (96%), sewerage (96%), telephone (41%)	

[a] Potential mushroom growers. [b] Mushroom growers.

2) Conventional agricultural activities

Most RHSs own agricultural land in which family members develop different activities, such as crop plants and livestock. Main agricultural activities performed by RHSs in the regions studied are shown in Table 3. In the region of Cuetzalan, primary activities involving traditional agriculture are predominant and oriented towards local food products (maize, beans, orange, banana, mammee), except for coffee and pepper which are commercial crops marketed by a cooperative. In the region of Toluca, most agricultural activities are mechanized and oriented towards commercial crops, such as maize, wheat, oat, and vegetables, as well as farm animals. This is why the average time devoted to these activities in the region of Toluca (14 days/year) is considerably lower than that in the region of Cuetzalan (128 days/year). However, yearly incomes (profits) received by RHSs are higher in the region of Toluca.

Table 3. Conventional agricultural activities developed yearly by the rural household system (RHS) in the regions studied.

Characteristic, activity or data		Region			
		Cuetzalan (RHSs= 89[a]) 1998-1999		Toluca (RHSs= 27[b]) 1999-2000	
		Range	Average	Range	Average
RHS	Without agricultural land (%)	9		18	
	With agricultural land (ha)	0.25-5 (91%)	1.1	0.25-37 (82%)	5.3
	Cultivated land (%)	99		73	
	Type of agriculture	Traditional		Mechanized	
	Governmental subsidies	Granted (57%)		Granted (14%)	
Crop plants	Maize (%)	92 (own consumption)		59 (to be marketed)	
	Wheat (%)	-		18	
	Oat (%)	-		18	
	Vegetables (%)	-		4	
	Beans (%)	93		-	
	Coffee (%)	98		-	
	Pepper (%)	57		-	
Fruit crops	Orange (%)	74		-	
	Banana (%)	63		-	
	Mammee (%)	36		-	

Livestock (%)	91 (hogs, fowls)		50 (fowls, hogs, sheep, cows)	
Overall time devoted to all activities (days per year; 8 h/day)	78-260	128	4-39	14
Cost of production (USD)	$ 10-700	$ 121	$ 300-5,200	$ 289
Incomes (profits, USD)	$ 50-6,000	$ 782	$ 200-15,000	$ 3,120

[a] Potential mushroom growers. [b] Mushroom growers.

3) Extra-agricultural activities

RHSs are disposed to carry out activities which are not directly related to agriculture for a number of reasons. These extra-agricultural activities for regions studied are shown in Table 4. RHSs from the region of Cuetzalan showed more diverse activities, such as gathering for own consumption and/or marketing occasionally, the making of produces, trading of produces from inside or outside the RHS, and agricultural labouring. However, the total yearly incomes (profits) received by RHSs in the region of Toluca were considerably higher (USD $ 15,491 per year) than those from the region of Cuetzalan (USD $ 1,338), despite that gathering and the making of produces were not important activities. The average time devoted to extra-agricultural activities in the region of Toluca (200 days/year) is also lower than that in the region of Cuetzalan (232 days/year).

Table 4. Extra-agricultural activities developed yearly by the rural household system (RHS) in the regions studied.

Activity or data		Region	
		Cuetzalan (RHSs= 89[a]) 1998-1999	Toluca (RHSs= 27[b]) 1999-2000
Utilization of the forest	Gathering for own consumption and/or marketing (%)	99 (firewood, wild plants, wild mushrooms)	33 (wild mushrooms, wild plants)
The making of produces (%)		24 (handicrafts, food products)	-
Trading, produces from inside or outside the RHS (%)		2	11
Labouring (%)		97 (agricultural labourer, services)	41 (services, building)
Overall time devoted to all activities (days per year; 8 h/day)		232 (range 70-280)	200 (range: 104-261)
Incomes (profits, USD)		$ 1,338 (range: $ 280-7,200)	$ 15,491 (range: $ 3,840-96,000)

[a] Potential mushroom growers. [b] Mushroom growers.

4) Cultivation of mushrooms

This is an extra-agricultural activity which was studied in the RHSs from the region of Toluca (Table 5), as mushroom cultivation in the region of Cuetzalan is carried out collectively by a cooperative in a central mushroom farm (Martínez-Carrera et al., 1998). Four main factors and their components were assessed: 1) The RHS, 2) Technology, 3) Capital, and 4) Market. The cultivation of edible mushrooms started around 1994 following a programme of technology transfer from the Ministry of Agricultural Development (SEDAGRO) in the State of Mexico. RHSs interested in this activity can be involved yearly, if they can provide up to 50% of the total investment. At present, mushroom cultivation in most RHSs is mainly

carried out by the head of the family, assisted by his wife and children in a few cases. The overall time devoted to this activity varies from 22-333 days per year, and mushroom consumption by the RHS has increased significantly. Most RHSs within the governmental programme received highly limited training (courses, conferences), technical assistance, and subsidy according to their mushroom production. A high proportion of RHSs manage to hire external labourers (range: 1-6) for regular wages to be involved in mushroom cultivation.

Table 5. Main characteristics from the RHSs performing mushroom cultivation as an extra-agricultural activity in the region of Toluca (1999-2000).

Characteristic		RHSs (n= 27)
Period of time engaged in mushroom cultivation (years)		3.6 (range: 0.5-6)
Family members involved (%)	Husband	70
	Wife	26
	Children	4
Overall time devoted to mushroom cultivation (days per year; 8 h/day)		100 (range: 22-333)
Mushroom consumption within the RHS (%)	Before cultivation	18 (occasionally)
	After cultivation	100 (average: 3 times per week)
Programme of technology transfer	Training (%)	85
	Number of courses taken	2 (range: 1-6)
	Technical assistance (%)	85
	Governmental subsidy (USD)	$ 2,022 (range: $ 500-6,000)
	Number of conferences	1-4 (RHS: 54%)
External labourers employed	Proportion (%)	52
	Number of labourers	2.4 (range: 1-6)
	Average wage per day (USD)	$ 5.64

General data about mushroom cultivation in the region of Toluca are shown in Table 6. RHSs have developed rustic facilities without environmental control for mushroom cultivation, using bricks, wood, plastic, and cardboard as building materials. Their size ranges from 80-2,500 m^2. Some RHSs (11%) have set up small laboratories for spawn production, due to the lack of spawn of sufficient high quality in the region. Its price varies from USD $ 1.20-2.10, and is usually produced by regional spawn makers which are not subjected to quality controls or regulations. Wheat straw + corn-cobs, wheat straw, barley straw + grass, and wheat straw + grass are commonly used as substrates for mushroom cultivation. Pasteurization is normally carried out by immersion in hot water; however, several RHSs are starting to pasteurize in tunnels. Most growing rooms have been adapted without a special design, using bricks, wood, plastic, and cardboard. There are white and grey oyster mushrooms produced in the region, which are selected by RHSs according to their growing conditions. In general, mushroom yields amongst RHSs range from 2.5-6 kg per 25 kg of fresh weight substrate. The spawning frequency (number of substrate batches per year) varies from 24-360, according to the facilities and time available within each RHS. The number of bags spawned per batch ranged from 10-200, giving a total mushroom production of about 25.8 tonnes per year in a RHS (range: 2.6-156 tonnes/year). Most oyster mushrooms are sold to intermediaries at the farm gate (56%), while selected mushrooms can be sold directly to consumers. A smaller proportion of the mushroom production is sent to the fresh market locally (33%) or to the main central markets from Toluca and Mexico cities (11%). This is mainly carried out by RHSs involved in mushroom production, as well as in mushroom marketing. Main by-products from rural mushroom cultivation in this region are spent substrates and plastic materials, which are occasionally recycled. Most RHSs (89%) think that mushroom cultivation is a profitable activity (Table 7). Their costs of production are generally low (USD $ 0.20-0.60/kg), while mushroom prices in the regional market can be as high as USD $ 3.00/kg. Sometimes,

several conventional agricultural activities within the RHS can be supported by incomes from mushroom cultivation.

Table 6. General data about the technological level of the RHSs performing mushroom cultivation and marketing in the region of Toluca (1999-2000).

Characteristic			RHSs (n= 27)
Facilities	Area (m^2)		507.7 (range: 80-2,500)
	Laboratory for spawn production (%)		11
	Substrate preparation (%)	Rustic	78
		Tunnel	22
	Growing rooms adapted (%)		70
	Growing rooms designed (%)		30
	Building materials		Bricks, wood, plastic, cardboard
Substrates (%)	Wheat straw + corn-cobs		78
	Wheat straw		14
	Barley straw + grass		4
	Wheat straw + grass		4
Spawn	Price (USD)		$ 1.70 (range: $ 1.20-2.10)
	Availability (%)	At the farm	11
		Region of Toluca	70
		Mexico city	19
Cultivated mushrooms (%)	White oyster mushrooms		41
	Grey oyster mushrooms		18
	Both		41
Mushroom yield (kg/25 kg fresh weight substrate)			5 (range: 2.5-6)
Spawning frequency (number of substrate batches per year)			109 (range: 24-360)
Number of bags spawned per batch			78 (range: 10-200)
Total production per year (tonnes)			25.8 (range: 2.6-156)
Form for sale (%)	Unselected mushrooms		85
	Selected mushrooms		15
Place for sale (%)	Farm gate		56
	Local markets		33
	Central markets (Toluca city, Mexico city)		11
By-products per year (tonnes)	Spent substrates		70 (range: 3-600)
	Plastic		0.389 (range: 0.020-2.5)

Table 7. Estimated financial analysis of mushroom cultivation developed by the RHSs from the region of Toluca (1999-2000).

Characteristic		RHSs (n= 27)
Cost of production per kilogram of oyster mushrooms (USD)		$ 0.40 (range: $ 0.20-0.60)
Mushroom price per kilogram (USD)		$ 1.87 (range: $ 1.30-3.00)
Incomes per year (profits, USD)		$ 31,805 ($ 2,880-225,600)
Perception of business profitability (%)	Very high	67
	High	22
	Low	11

5) Fundamental trends of rural mushroom cultivation

Rural mushroom cultivation is a recent activity in the region of Toluca. It was found that RHSs can easily adopt and adapt this biotechnology to their own needs, keeping a proper balance with other agricultural and extra-agricultural activities. In fact, mushroom cultivation becomes an extra-agricultural activity which can provide additional incomes, labour opportunities, and food to the RHS, encouraging household members to remain in the community. Three types of RHSs were defined on the basis of the level of integration of mushroom cultivation within the RHS: 1) Constant grower (CG): mushroom cultivation is established as the main extra-agricultural activity, leading to the reduction or displacement of less profitable or important productive activities; 2) Frequent grower (FG): mushroom cultivation is integrated proportionally to the rest of agricultural and extra-agricultural activities; and 3) Occasional grower (OG): conventional agricultural and extra-agricultural activities remain, and mushroom cultivation is carried out occasionally. According to this typology, three regions can be identified for RHSs located around the main urban centres of mushroom consumption: 1) Near the market, 2) Intermediate distance from the market, and 3) Far from the market. This is the case of the region of Cuetzalan, where mushroom cultivation has to be developed by a cooperative in a central mushroom farm to satisfy a small local market (*ca*. 111-945 kg/month). This region is far from a main mushroom market, so the development mushroom cultivation by RHSs is limited despite their appropriate social, economic, and ecological conditions.

Mushroom biotechnology brings about social (improvement of local diet; participation of peasant women in the production process, organization), economic (incomes, labour opportunities), and ecological (efficient use and recycling of agricultural and forestry by-products) advantages when incorporated to rural development (Martínez-Carrera, 2000). Considering our research results and data from other rural areas in Mexico (Martínez-Carrera et al., 1998), it is possible to establish that fundamental trends of rural mushroom cultivation are directly associated to main mushroom markets. These markets are centralized and demand fresh mushrooms as the main commercial product which is highly perishable (Martínez-Carrera et al., 2000). At present, most RHSs in the country can only carry out mushroom production on a low scale for the fresh market due to their limited socio-economic conditions and capacity for marketing. Their impact is mainly observed within the community system, decreasing towards the regional and global systems. Accordingly, those RHSs operating as CGs are normally located near the market, FGs are at an intermediate distance from the market, and OGs are far from the market (Fig. 2). Depending on this location, RHSs take advantage differentially from the social, economic, and ecological aspects of mushroom cultivation. Governmental programmes for rural development actually drive this differential impact through the financial support to RHSs for developing productive projects which highlight the economic impact (CGs, FGs), or for social projects against poorness in remote regions (OGs). Thus, the farther a RHSs is from a main mushroom market, the higher social and ecological impact is expected.

Future development of rural mushroom cultivation can be promoted thoroughly by marketing strategies oriented towards a significant increase in the national consumption of processed mushrooms. This will permit RHSs to evolve dynamically and economically, mainly those located far from the main mushroom markets, taking advantage of processing technologies, such as cooling, vacuum cooling, freezing, controlled atmosphere storage, canning, and drying. RHSs developing mushroom processing will gradually have a further impact on the regional and global systems.

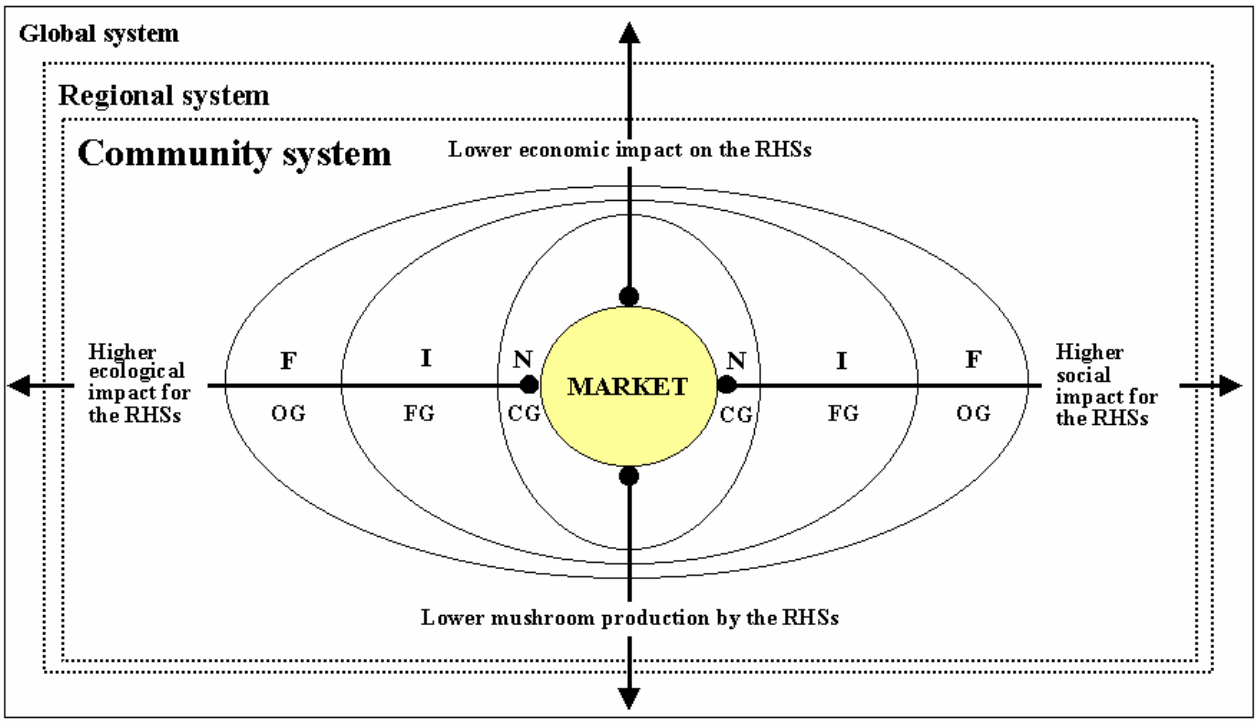

Fig. 2. Fundamental trends of rural mushroom cultivation in Mexico. Rural household systems (RHSs) operating as constant growers (CG), frequent growers (FG), and occasional growers (OG), are normally located near (N), at an intermediate distance (I), or far (F) from the main mushroom market. Depending on this location, RHSs take advantage differentially from the economic, social, and ecological aspects of mushroom cultivation.

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