Analysis of Local Economic Impacts Using a Village Social Accounting Matrix: The Case of Oaxaca

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Abstract This chapter describes a methodology to estimate a local economic model based on a social accounting matrix (SAM), for the district of Villa Alta within the Sierra Norte region of the Mexican State of Oaxaca. The estimates combine secondary statistics with data obtained through a direct survey. A SAM based model is then used to assess the impact of a rural development program on the local (village) and regional (state) economy.

Keywords Social accounting matrix · Local economy · Economic impact
Rural development

1 Introduction

The applied economic research literature over the last years has collected studies focusing on project economic impacts using different evaluation techniques. Some of the limits of this kind of analysis are related to the fact that only selected beneficiaries and variables directly linked to projects/programs are accounted for, and is therefore not possible to capture the main impacts on the overall economy. Computable General Equilibrium (CGE) and Social Accounting Matrix (SAM) models can be used to fill this gap.

The aim of the present investigation is to assess the economic impact of a rural development programme[1] on a local (village) and regional (state) economy using a SAM model. More specifically, this research shows whether, and under which

[1]While acknowledging the distinction between programme and project, we opted to use the two terms interchangeably for the purpose of this research.

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conditions, a rural development project that includes Climate Change Adaptation strategies (such as the Adaptation for Smallholder Agriculture Programme, ASAP) would trigger economic growth in a region or in a group of villages within a specific geographical area.

The study applies an innovative methodology for estimating village-wide SAMs, which builds on the most recent literature on the subject, and integrates estimation methods by the World Bank and the Italian Government (Scandizzo et al. 2010, 2015). The SAM methodology identifies investment impacts on: (i) household income; (ii) household welfare; (iii) productive sectors; and (iv) local administration. We expand this method to make a direct comparison among three project scenarios, controlling for different types of investment projects and relative total costs. This approach allows us to quantify the extent to which a climate adaptation intervention would enable the local economy to achieve more stable paths of economic growth. Furthermore, our methodology distinguishes between short-medium term and long term expected impacts on the different economic and social sectors, thus increasing the informative capacity of the analysis performed.

We test the methodology in a small geographic area, the district of Villa Alta within the Sierra Norte region in Oaxaca State (Mexico). As a result of the direct comparison between three different project scenarios implemented over a period of five years, we identify which of the socio-economic sectors are benefitting from each programme intervention. Through this research, we contribute to generate more evidence-based decisions on investments project designs that aim to stimulate rural economic development and include Climate Change Adaptation strategies.

The plan of the Chapter is as follows. Section 2 begins with a theoretical discussion on SAM methodologies. Section 3 discusses additional practical implication for the SAM estimation at regional and local level. Section 4 presents the expected outcomes for the scenarios envisaged. Section 5 concludes.

2 The SAM: Theoretical and Methodological Aspects

The Social Accounting Matrix (SAM) is considered an extension of the traditional Input—Output[2] (I/O) model proposed by Leontief (1966), which records in monetary terms the exchange flows occurred within an economic system, during a specific period of time (usually an year). The Matrix allows to consider the entire structure of relations characterizing an economic system through the different phases of the production, distribution, utilization and income accumulation process.

As shown in Fig. 1, any economic system can be described by the circular income circuit where economic agents, productive sectors and institutions are connected to one another through real transactions. For example, households' incomes are related to remuneration of capital and labor, government assistance in the form of social

[2]The Input—Output accounts provide detailed industry and commodity accounts and show the supply and demand flows in a specific economy.

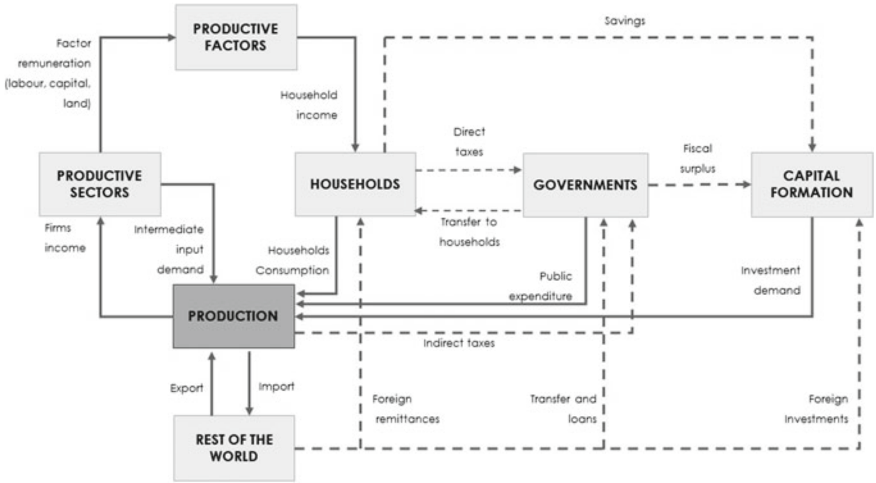


Fig. 1 The income circuit

transfers, and foreign remittances from the Rest of the World.[3] Conversely, families decide to allocate their wealth on both consumption and savings following their preferences, once taxes—both direct and indirect—are paid. In such a comprehensive framework, each actors' outflow becomes someone else's inflow and, considering that all transactions between people and institutions are monitored and quantified, the system does not present leakages.

A SAM thus consists of a set of interrelated subsystems that, on the one hand, provide the analytical framework of the economy studied by tracking monetary flows occurring between sectors and, on the other hand, measure the structural changes within the economy (injections and multiplying effects in the system), as a result of policy changes or a project interventions.

The information is compiled in a double-entry table (the matrix), describing the structure of the economic system through disaggregation in key blocks (actors, productive factors and activities), assumed as origins and destinations of the transaction flows. Each key block is further disaggregated into accounts headed to the institutional sectors (e.g. type of households, specific commodities, production sectors) depending on the detailed data availability. The economic system is typically disaggregated into the following blocks:

i. Primary production factors (Labour and Capital);
ii. Households (eventually disaggregated by income or income source);
iii. Government (Public Administration);
iv. Production sectors and Commodities (Agriculture, Industry, Services and their disaggregation);

[3]The Rest of the World can be defined as another Country/State, Region or geographical area depending whether the scale of the analysis is National, Regional or Local-wide respectively.

	Productive Factors	**Household**	**Government**	**Production sectors and Commodities**	**Savings and investment**	**Rest of the World**	**Total inflows**
Productive Factors		Domestic Employment	Government Employment	Value-added		Payments from abroad	Total factor income
Household	Labour incomes and profits	Inter-household transfers	Social transfers			Foreign remittances	Total household income
Government	Taxes on labour and profits	Direct taxes		Indirect taxes	Taxes from capital account	Foreign grants and loans	Total Government income
Production sectors and Commodities	Domestic supply	Private consumption	Recurrent spending	I/O Matrix (intermediate demand)	Investment and stock	Export payments	Total demand and activity income
Saving and Investment		Private savings	Fiscal surplus			Current account balance	Total savings
Rest of the World	Factors payments abroad	Household transfer	Government transfers	Imports payment			Total imports
Total outflows	Total factors spending	Total Household expenditure	Total Government Expenditure	Total Gross output	Total investment spending	Total Export	

Fig. 2 A simplified SAM scheme (*Source* Own elaboration)

v. Savings and Investment (Public and Private gross fixed investments);
vi. Rest of the Country (ROC) or Rest of the World (ROW).

In a typical SAM structure, columns represent the outflows of the different economic agents that is, the expenditure of any aggregate with respect to the others, while rows represent the inflows, namely the income formation. Since total incomes equal total expenditures and material balances between demand and supply mist also hold,[4] a SAM is a square and balanced[5] matrix. A simplified scheme of the SAM is presented in Fig. 2.

An interesting evaluation in the context of developing countries relates to the simulation of structural changes of the economy in response to policy changes. Some exemplary questions to which this analysis could respond are: What would happen to the economy if technical change in agricultural production were brought in? How would the economy change after a shift in import? What would be the trickle-down effect due to the establishment of a new production activity?

All these interventions cannot be simply studied as the effects of an increase in households' disposable income, since changes in the economy have potential important effects on the structure of the SAM in terms of coefficients and multipliers. For instance, long lasting impulses in the Agricultural sector (as in the form of ODA interventions) would generate an increase in rural household income that would trigger a rise in goods and services demand. Thereafter, a likely increase in goods and services supply would generate a structural change within the local economy.

For this reason, we can base ours simulation on a variation of the linear Input—Output model, according to the equation (Scandizzo and Ferrarese 2015):

[4]Surplus or deficit in the balance of trade are compensated within the "rest of the world" account.

[5]A square matrix contains an equal number of rows and columns while a Matrix is balanced when the sum (total value) of each row is equal to the sum (total value) of each column for each of sectors included.

$$\Delta X = (I - A^*)^{-1}[(\Delta A)X + \Delta Y]$$

where A and A* are the SAM matrices, respectively, with and without the Adaption for Smallholder Agriculture Programme (ASAP) component, and ΔY is the vector of exogenous changes in receipts or expenditure of the capital account (Project intervention or exogenous investment). In our specific case, $\Delta Y = 0$, since the policy examined consists only in the selective change in the sector coefficients interested by the project intervention.

In the case of Oaxaca the evaluation consists of a two-step process. The first step relates to the evaluation of an investment programme at regional scale, with and without the ASAP component. Using the Oaxaca SAM, we evaluate the short-term effects of the project in the five investment years, and the effects of the expected mid-long term structural change of the local economy, in response to the project and the related climate change adaptation measures.

The second step consists in assessing project effects on the targeted economy. In order to perform this evaluation we need to scale down the project at village level using the local SAM presented above. As in the analysis at regional level, the estimation procedure will consider short and long term effects on the local targeted area, differentiating impacts related to the ASAP inclusion or exclusion.

2.1 The Local SAM

CGE modelling and SAM-based research require the use of the most recent economic data available in a coherent framework. However, these data generally come from quite diverse sources of information such as Input—Output tables; national accounting data; households, firms and enterprise surveys; Sector-wide census; labour market surveys; government and international trade accounts. One of the main issues when constructing a SAM both at national and local level is how to combine and incorporate information, harmonizing both primary and secondary dataset, derived from previous periods.

While the original idea was based on the articulation of national accounts, the structure of a SAM appears particularly appealing to represent the interconnections of a smaller economy, such as a region, a town, a village or a group of villages, particularly in the process of investigating the aspects of the mutual relationships of obligation and exchange that characterize local communities. In this respect, a SAM can be used with a twofold aim to:

(i) focus on the local detail of the linkages among disaggregated production and consumption activities (agricultural production, rural works, personal services, etc.), and,
(ii) quantify the monetary and non-monetary transactions within and between the households and the formal and informal community groupings.

Because of its characteristics of a balanced network of exchanges among a variety of producers and users, a local SAM can also capture some of the more subtle linkages that characterize social cohesion, cooperative behaviour and institutional strength in a small community. These linkages may lead to estimates of multipliers and indicators of growth capacity that depend on the relational structure of the community, rather than merely on its resource endowments and performance indicators. In addition, the same linkages may shed lights on the phenomenon of development as a result of complex interactions between competitive and cooperative interrelations in a local context, and on the importance of network closure—dense connections between network participants—in maintaining trusting relationships and building up social capital (on this, see, for example Coleman 1988).

Depending on the degree of integration with external markets, villages are characterized by stronger or weaker market interactions amid village households. Following a U-shaped relationship, market interactions tend to be stronger in case all goods are non-tradable between villages, while they are weaker in economies perfectly integrated with external markets. The villages in our study could be depicted as in Fig. 3.

Compared to the more aggregate SAMs, local SAMs try to capture the complexities of a closely integrated, but small socio-economic systems. In fact, a village SAM is based on a representation of a local economy which has considerable more breadth and depth and, as such, demands a closer investigation of the elements of modularity and interconnection characterizing the structure of village life. Because of social capital, a local SAM spans a broader set of functions and non-monetary transactions, for example, payments in kind, reciprocal exchanges, management of the commons, social rewards and sanctions and a variety of social rites and customary activities.

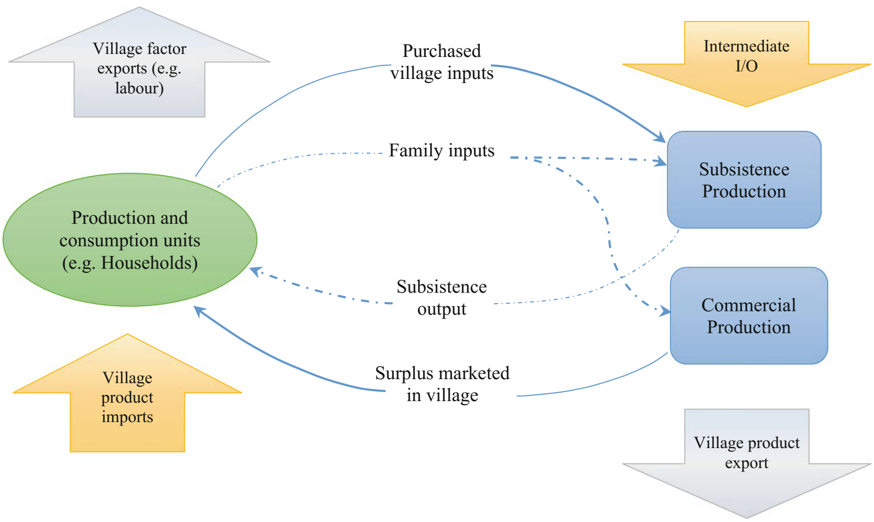


Fig. 3 Economic flows in a village with intermediate degree of interaction with external markets (*Source* Own elaboration)

Furthermore, owing to of the higher disaggregation level of economic activities, a local SAM may contain a deeper analysis of the productive relations, with a finer detail of agricultural activities, rural industries, small business and personal services (Taylor et al. 2006).

From the point of view of the target group, or the nodes of the social network, a village SAM may also include stakeholders other than the classical groupings defined in national accounts in order to capture, for example, exchanges within the extended family and repeated interactions, such as those occurring between farmers to govern the distribution for irrigation water. While households and firms may be disaggregated into finer categories, village level institutions may also be included in a local SAM as important nodes of interdependencies within the local community.

The integration of specific primary data information coming from the household, the business and the community questionnaires into a unique dataset, allowed tracking down the exchange relations between the sectors characterizing the economic system.

2.2 Literature Review of Local SAM

One of the first studies on local level SAM has been implemented by Bell, Hazell and Slade (1982) who analysed the effects on paddy land of an irrigation project for the Muda River basin. The authors focused on the evolution of some key variables (output, income, wage and rent) to estimate direct impacts of the project by means of a linear programming model. Indirect effects have been analysed developing a Social Accounting Matrix model at regional level. The regional SAM was disaggregated into forty-five accounts. Results of the analysis showed an increase in the regional value added but no changes in the distribution of income within the region.

Years later, Adelman et al. (1988) were the first to undertake a study and construct a village level SAM. The authors constructed a SAM using household data collected from a major migrant-sending village in Central Mexico in 1982 and focused on the economic structure of such economy. The study highlighted the importance on internal and international migration in the village economy. Findings showed that national and international migration has a central role in the village economy and that stressed the vulnerability of the village economy to external shock resulting from U.S immigration policy reform. Further, it showed how anti-poverty policies are crucial in addressing the problem of landless households.

Subramanian and Sadoulet's study (1990) elaborated a village-wide SAM for the village of Kanzara in Western India. The SAM was used to estimate the effects of an irrigation investment program in this cotton-producing and rain-fed area. Given the agricultural nature of the village, fewer commodity—producing activity sectors were considered in the SAM which instead provided greater details on services, labour flows, transfers, and income distribution.

An interesting town-based analysis through a SAM was carried out by Lewis and Thorbecke (1992). The analysis focused on a Kenyan town Kutus, comprising both the town population—of around 5,000 inhabitants—and the 8 km zone around it (hinterland) with a population of 42,000 people. The SAM was used to test the governmental assumption of agriculturally-driven regional economies and to evaluate non-agricultural production sector activities in the Kutus region. According to the authors, agricultural activities were indeed very important for stimulating regional output and income.

A vast and diverse set of issues have been analysed through Village-SAMs—from the impact of remittances from Mexican workers abroad or in urban centres (Adelman et al. 1988) to the impact of decentralized rural industrialization on employment, incomes and modernization trends within the village (e.g. Parikh and Thorbecke 1996); or the nutritional consequences of different exogenous policies (e.g. Ralston 1992).

Extensive application of village-SAM analysis is done by Taylor and Adelman (1996), which they applied to India, Indonesia, Kenya, Mexico, and Senegal. In their book—Village Economies—the authors present a general framework for modelling village economies based on computable general-equilibrium techniques. They estimate models for villages and a village-town and conduct a series of comparative experiments. In addition, they built a complementary CGEs calibrated and designed to capture the impact of policy, market and environmental changes on the different village economies.

Taylor et al. (2006) extend village SAMs to include household groups as well as separate components of a rural economy. In this type of model each “household level SAM” or rural group is integrated into a rural sector “mega-SAM”. The SAM provides the data input into the micro economy-wide, CGE model.

A different microeconomic modelling approach is used by Subramanian and Qaim (2009) used to analyse welfare and distribution effects in a typical village economy in India. Unlike previous SAMs, which were based on sample surveys, their SAM was built on a village census and considered 156 agricultural and non-agricultural activities. Cotton production and numerous other crops are included within the Agricultural activities accounts. Non-agricultural activities included other village-based production (e.g. construction) and agriculture services (e.g. hiring out machinery), retail trade, private services (for example, doctor, barber etc.), government services (for example, ration shop, post office) and transportation.

2.3 A General Framework for Village-SAM Analysis

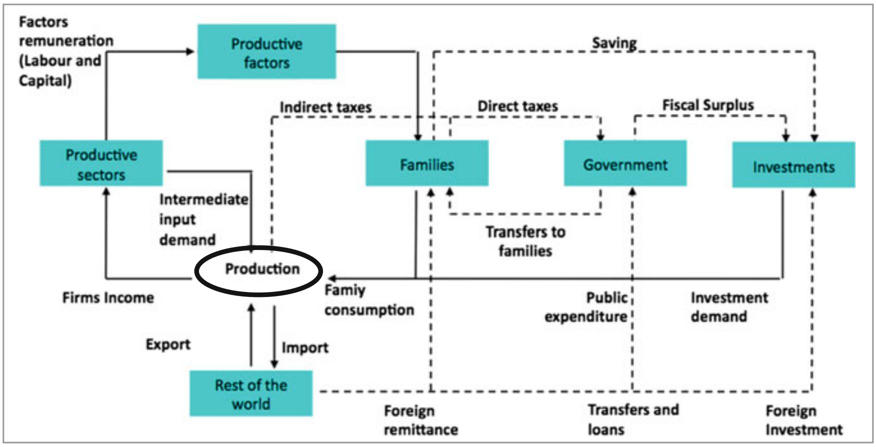
A typical village SAM can be described as essentially a scaled-down version of a national or regional SAM. In particular, the following sectors can be considered for the village-SAM structure:

Production activities: Production sectors normally included in the SAM are: (1) crop production—coffee, cocoa, wheat, maize, other pulses, oilseeds, cotton, fruits and vegetables, and other crops (cultivation of these crops could be divided for irrigated and rain-fed areas, but in SAM we can have only one column for each crop); (2)

animal husbandry—milk and milk products, wool and meat, cow dung manure, and bullocks; (3) construction; (4) service providers and the self-employed—small shops, grocery, fruit and vegetable vendor, cloth shop, general shops, transport, carpenter, and other services; (5) manufacturing—cotton ginning factory; and (6) services—-government services (education, welfare) and private services.

Factors of production: Factors of production included in the village SAMs are tipically: (1) Labour—divided by sex; and (2) Capital, measured as income from managing one's enterprise—in various forms, including mixed income from the self-employed.

Institutions: Institutions considered in village SAMs are normally: (1) households divided by family size and by occupation—small, medium, large farmers, labour, self-employed in non-agriculture, service, and other households; and (2) government at various levels depending on the depth and breadth of the analysis (local, district, provincial).



The construction of village-level SAMs can be a challenging task, considering the possibility to consider and to investigate both monetary and non-monetary transactions within a small community, and the need to collect primary data and household census data to represent these transactions. A typical description of local SAM would include: (*i*) *Primary Production Factors;* (*ii*) *Natural resources;* (*iii*) *Stakeholders,* (*iv*) *Production sectors;* (*v*) *Capital formation,* (*vi*) *Rest of the world.*

Transactions between the village and rest of the world are recorded in the Rest of World accounts. Depending on the geographical area of the analysis, The Rest of the World account can be further disaggregated into three different components including Rest of the Area, Rest of the Country and Rest of the World to describe domestic and international trade.

3 The Regional SAM of Oaxaca

3.1 Estimating the Oaxaca SAM

While no recent estimation of the Social Accounting Matrix for the Oaxaca region appears to be available, we were able to use Input—Output estimates made by Bautista (2008) and Martinez Jimenez (2012) integrated with economic data 2004/2010 collected by the Research Team of the Global Trade Analysis Project (GTAP) and INEGI. We thus estimated using a computational algorithm (Scandizzo and Ferrarese 2015) a regional SAM consisting of 4 agriculture economic sectors, 11 industrial sectors, 4 services sectors, 2 production factors, 2 institutions (Household and Government), Capital Formation and The Rest of the World and rest of the Mexico (see Table 1: SAM sectors).

Table 1 SAM sectors for the Oaxaca region

Productive sectors	Production factor
Agriculture	Labour
Animal	Capital
Forestry	
Fishing and hunting	
Mining	
Food, beverage and tobacco	
Textiles and textile products, leather and leather products	
Wood and wood products	**Institutions**
Paper and paper products, publishing and printing companies	Households
Manufacture of coke and refined petroleum products	Government
Mineral	
Metal product	
Manufacturing	
Construction	
Electricity, gas, steam and water supply	
Wholesale, restaurant and hotels	**Other sectors**
Transport storage and communications	Capital formation
Finance and real estate	Rest of the Mexico
Social and personal services	Rest of the world

3.2 Villages Profiles

In order to develop the estimates of the Village SAM for Oaxaca we conducted a statistical survey of two municipalities within the Villa Alta district, precisely in: (i) San Ildefonso Villa Alta and (ii) San Cristóbal Lachirioag.

The two communities are located in the northern eastern part of Oaxaca in the centre of the Sierra Norte region at about 140 km to Oaxaca de Juarez at an altitude of 1200 mt (3939 ft.). San Cristobal Lachirioag total area is of about 24.24 km^2 which represent the 0.03% of Oaxaca state while San Ildefonso Villa Alta covers a larger total area of 136 km^2 (0.14% of Oaxaca State).

The Villa Alta municipality includes, among others, the villages of San Juan Yalahui, San Francisco Yatee and San Jaun Tagui which have been part of the study. The total population of two municipalities is of 4,708 peoples (INEGI 2012). The first production activity within the target area is agriculture and in the observed villages there is only one exporting industry (Mezcaleria).

3.3 Survey Descriptive Statistics

To estimate the local SAM and analyse relevant sectors of the village matrix, we collected data through households and business-activities surveys in each of the above mentioned communities. In detail, we have gathered values on several variables such as output of crops and other activities; inputs of land, labour, capital, and purchased inputs, food and non-food consumption expenditures and pattern over time, public and private transfers, saving and remittances flows, economic shocks, climate change and adaptation strategies. Preliminary meetings with local authorities were held in each of the communities visited so as to being officially introduced to the inhabitants and get a better understanding of both the local government spending and the village formal and informal markets.

For household data we opted for a Random sampling technique[6] with the intention of reducing the likelihood of bias favouring, wherever possible, women's interviews since they are considered a more accurate and reliable source of information. The household sample consisted of 520 people (335 females and 285 males) representing 104 households. Seven local enumerators helped the team during data collection.

The data collected show that 20% of the population does not carry out any agricultural activity—despite the fact that minimal production for household consumption is generally present—while over 24% of population live exclusively on agriculture (hereafter defined as Farmers). More than half of the population (54%) relies both on agriculture and other activities. Figure 4 describes how agriculture production contributes to poor households' incomes.

[6]Random sampling is a sampling technique where we select a group of subjects (a sample) for study from a larger group (a population). Each individual is chosen entirely by chance and each member of the population has a known, but possibly non-equal, chance of being included in the sample.

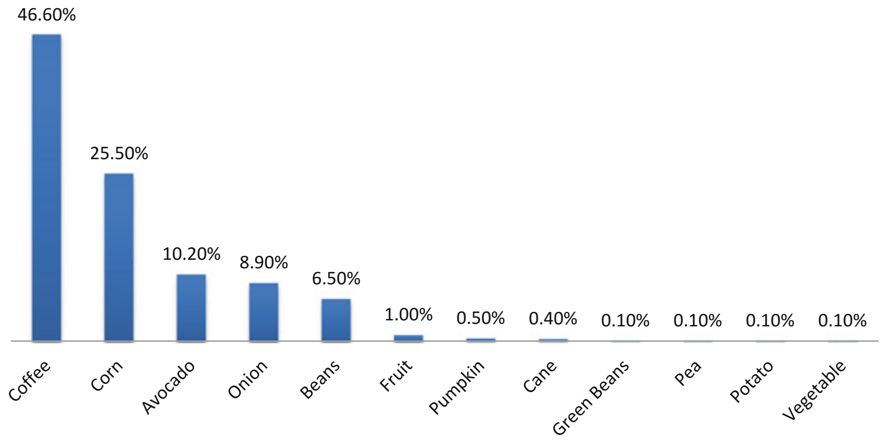


Fig. 4 Crop production value of poor households

The "non-poor" households, mostly with a double activity, are well integrated the local economy and also interact with neighbouring communities. The main activities carried out by this categories are: (i) Food store; (ii) Restaurant; (iii) Hardware; (iv) Blacksmith; (v) Internet Point; (vi) Household goods store; (vii) Bakery; (viii) Taxi; (ix) Other store.

In order to include the business section in the matrix we have surveyed 50 different shops in the various communities covering at least one shop for each business sector.[7] Even for this data collection process we opted for a random sampling technique, while considering as well spatial aspects such as proximity to the main road, visibility and ease of access. To the extent possible, we tried to cover the majority of villages' shops including those not immediately accessible. Table 2 summarizes the mean values of costs, revenues and profits and presents a breakdown for revenues' composition.

3.4 Estimating the Village SAM

Thanks to the information collected through the survey we identified 30 socio-economic sectors relevant in the local economy:

Some of these sectors represent the typical services produced and consumed by rural households and other productive sectors in the target area, while others pertain to goods and services consumed in the area but produced in a different region/community.

From the coefficient matrix we then estimate the ***Multiplier matrix***. The latter describes the effects of an exogenous expenditure on the economic system. Similarly

[7]Despite Mezcal production is a common practice in the communities we visited, only one person was formally running a prolific business activity on it.

Table 2 Business activities

	Revenue (pesos)	Costs (pesos)	Profit (pesos)	Labour costs (pesos)	Other costs (pesos)	Internal sales (business) (%)	Internal sales households (%)	Sales to institutions (%)	Sales to other communities (%)	Sales to the rest of Oaxaca	Sales to the rest of Mexico (%)	Sales to the rest of the world (%)
Food and beverage	20,911	14,444	6,467	2,000	11,518	–	80	–	20	–	–	–
Public phone	19,000	17,500	1,500	–	–	50	50	–	–	–	–	–
Restaurant	37,000	30,400	6,600	–	27,000	–	17	–	67	–	16	–
Transport	20,000	19,000	1,000	–	–	–	95	–	5	–	–	–
Carpentry	82,500	55,100	27,400	–	–	10	7	–	83	–	–	–
Hard industry	150,000	120,000	30,000	8,000	–	–	20	10	70	–	–	–
Construction	57,400	–	–	–	–	–	50	–	50	–	–	–
Internet point	72,500	30,300	42,200	–	–	25	50	5	20	–	–	–
Beauty shop	8,160	1,560	6,600	–	–	–	50	–	50	–	–	–
Oil	32,400	–	–	–	–	–	80	–	20	–	–	–
Mezcaleria	1,200,000	960,000	240,000	360,000	–	1	2	–	2	–	1	94
Boutique	80,000	56,000	24,000	–	–	–	100	–	–	–	–	–

Productive sector	Value added
Agriculture	Capital
Coffee	
Maize	
Avocado	
Spring onion	
Rest of agriculture	Labour
Mezcaleria	
Oil	
Energy	
Telecommunication	
Construction	
Food and beverage	
Accomodation and restaurants	**Institutions**
Transport	Farmers HHs
Carpentry	No farmers HH
Metalurgy	Government
Hardware	
Internet point	
Beauty shop	
Gas station	
Clothing shops	**Other sector**
Other shops	Capital formation
Repair services	Rest of Mexico
Instruction and public services	Rest of the world

to the Keynesian Multiplier, an initial expenditure of one MU in a specific sector will generate impacts equal to the multiplier factors to the respective interlinked sectors.

Starting from the Multiplier matrix we can generate the Restricted[8] Multiplier (Forward and Backward multipliers). Forward multipliers express the increase in the activity level of a particular sector in response to an equi-proportional increase in all sectors. They thus measure the importance of the sector considered as a supplier of goods and services and, in a broader sense, the capacity of a sector to participate to overall growth. Sectors possessing low forward multipliers indicate that these industries sell their output mostly to final demand and depend mostly on intermediate flows. Backward multipliers, on the other hand, measure the extent to which a sector autonomous rise in activity level spills over all the other sectors. Therefore they measure the importance of a sector as a centre of demand for the rest of the economy,

[8]The multipliers are defined "restricted" because the balance of payment is assumed to be constrained by the base year conditions, so that exports are prevented from growing to match the increase in imports.

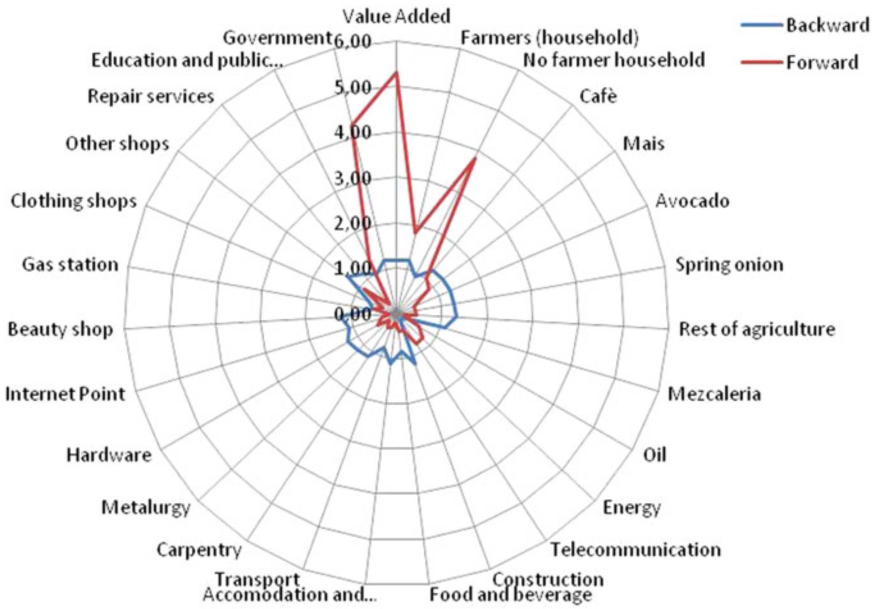


Fig. 5 Backward and forward multipliers

and can be considered as an index of the positive externalities generated by the network structure, which relates to the capacity to propagate a shock from one to other sectors. Those sectors characterized by low backward multipliers indicate that their dependence on other sectors for their inputs is comparatively very low, i.e., their principal inputs are provided mainly by imports.

In conclusion, forward linkages determine the relationship between the activity in one sector and its sales to others. Backward linkages display the relationship between the activity in a sector and its purchases from the others. In the case of the municipalities analysed, the sector with highest multiplier mean value are Coffee, Maize, Avocado, Spring Onions (cash agriculture) and public services. The key results of our estimation on the Local SAM restricted multipliers are summarized in Table 3 and Fig. 5.

Using the data of foreign expenses in the community we can estimate the multiplier effect for each Peso spent in the village. As it could be expected, given the socio-economic context of the area, Households and Services appear to be the most sensitive sectors. These results can be certainly justified observing that these two sectors are the most connected, therefore those with the highest capacity to spread the initial shock over the rest of the economy. The multiplier for value added is equal to 1.254 which means that each peso injected in the target area creates 1.254 pesos of value added in the village economy. Table 5 shows the results (Table 4).

To evaluate the multiplier effect in the study area we can simulate different investment scenarios. The following tables and figures depict the effects of alternative

Table 3 Local SAM, restricted multipliers

	Backward		Forward	
	Total	Mean	Index	Mean
Value added	1.17	0.26	5.30	1.16
Farmers (household)	1.22	0.27	1.83	0.40
No farmer household	0.91	0.20	3.82	0.84
Cafè	1.25	0.27	1.02	0.22
Maize	1.27	0.28	0.90	0.20
Avocado	1.27	0.28	0.42	0.09
Spring onion	1.27	0.28	0.41	0.09
Rest of agriculture	1.33	0.29	0.43	0.09
Mezcaleria	1.10	0.24	0.17	0.04
Oil	0.17	0.04	0.57	0.13
Energy	0.17	0.04	0.78	0.17
Telecommunication	0.17	0.04	0.81	0.18
Construction	1.19	0.26	0.39	0.09
Food and beverage	0.85	0.19	0.41	0.09
Accomodation and restaurants	1.12	0.24	0.21	0.05
Transport	0.81	0.18	0.33	0.07
Carpentry	1.13	0.25	0.37	0.08
Metalurgy	1.18	0.26	0.23	0.05
Hardware	1.23	0.27	0.49	0.11
Internet point	1.08	0.24	0.36	0.08
Beauty shop	1.24	0.27	0.18	0.04
Gas station	0.53	0.12	0.51	0.11
Clothing shops	0.66	0.15	0.33	0.07
Other shops	1.35	0.30	0.88	0.19
Repair services	1.14	0.25	0.27	0.06
Education and public services	0.98	0.21	1.34	0.29
Government	1.20	0.26	4.25	0.93

investments in cash agriculture, transport, services or government transfers to households. The results show a larger than unity effect on local value added in the case of agriculture investment, while the biggest impact on local industry and services are provided in the case of investment in transport services.

Another interesting simulation concerns the likely impact generated by remittances flows towards the area. Remittances represent 25% of farmers' total income and 40% of the income for other households. Remittance flows show a leverage capacity on value added of 1, 8 (11%) and 4, 7 (28%) million pesos respectively for farmers and other households. In the case of farmers the sectors with the larger effect

Table 4 Local SAM, restricted multiplier

	Multiplier
Value Added	1.254
Farmers (household)	0.394
No farmer household	0.865
Cafè	0.180
Maize	0.155
Avocado	0.047
Spring onions	0.045
Rest of agriculture	0.056
Mezcaleria	0.000
Oil	0.077
Energy	0.133
Telecommunication	0.139
Construction	1.188
Food and beverage	0.048
Accomodation and restaurants	0.009
Transport	0.115
Carpentry	0.101
Metalurgy	0.014
Hardware	0.295
Internet Point	0.037
Beauty shop	0.002
Gas station	0.097
Clothing shops	0.035
Other shops	0.159
Repair services	0.024
Education and public services	0.317
Government	1.256

are agriculture and in the case of other households cash agriculture and services. In general the remittances contribute for over 40% of total GDP creation for the Villa Alta area (Fig. 6).

4 Project Description

In order to assess project's effect on the targeted areas we hypothesized a typical IFAD investment programme of 20 USD million of which 7 million relates to ASAP

Table 5 Local SAM, alternative investment allocation

	Cafè	Maize	Avocado	Spring onion	Transport	Education and public services	Farmers (household)	No farmer household
Value added	1.776	1.806	1.806	1.815	0.455	1.334	1.417	0.880
Farmers (household)	0.556	0.565	0.565	0.568	0.143	0.417	1.444	0.276
No farmer household	1.223	1.244	1.244	1.250	0.314	0.919	0.977	1.607
Cafè	1.255	0.259	0.259	0.260	0.066	0.191	0.484	0.207
Maize	0.219	1.223	0.223	0.224	0.057	0.165	0.438	0.169
Avocado	0.067	0.068	1.068	0.069	0.017	0.050	0.091	0.071
Spring onion	0.064	0.065	0.065	1.065	0.016	0.048	0.075	0.073
Rest of agriculture	0.079	0.080	0.080	0.081	0.020	0.059	0.178	0.051
Mezcaleria	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001
Oil	0.041	0.040	0.040	0.036	0.642	0.022	0.055	0.023
Energy	0.170	0.173	0.173	0.173	0.053	0.127	0.229	0.180
Telecommunication	0.168	0.171	0.171	0.171	0.066	0.235	0.144	0.206
Construction	0.022	0.023	0.023	0.023	0.012	0.024	0.019	0.025
Food and beverage	0.068	0.069	0.069	0.069	0.017	0.051	0.098	0.069

(continued)

Table 5 (continued)

	Cafè	Maize	Avocado	Spring onion	Transport	Education and public services	Farmers (household)	No farmer household
Accomodation and restaurants	0.013	0.013	0.013	0.013	0.003	0.009	0.010	0.016
Transport	0.027	0.027	0.027	0.027	1.087	0.020	0.058	0.017
Carpentry	0.044	0.045	0.045	0.045	0.020	0.032	0.039	0.053
Metalurgy	0.017	0.017	0.017	0.017	0.006	0.012	0.014	0.020
Hardware	0.057	0.058	0.058	0.059	0.018	0.035	0.047	0.053
Internet point	0.047	0.047	0.047	0.048	0.022	0.034	0.047	0.054
Beauty shop	0.003	0.003	0.003	0.003	0.001	0.002	0.002	0.004
Gas station	0.052	0.050	0.050	0.045	0.813	0.028	0.070	0.029
Clothing shops	0.049	0.050	0.050	0.050	0.013	0.037	0.039	0.064
Other shops	0.224	0.228	0.228	0.229	0.058	0.168	0.179	0.295
Repair services	0.030	0.031	0.031	0.031	0.048	0.022	0.044	0.029
Education and public services	0.269	0.273	0.273	0.273	0.155	1.285	0.240	0.251
Government	0.870	0.879	0.879	0.880	0.660	0.454	0.751	0.658

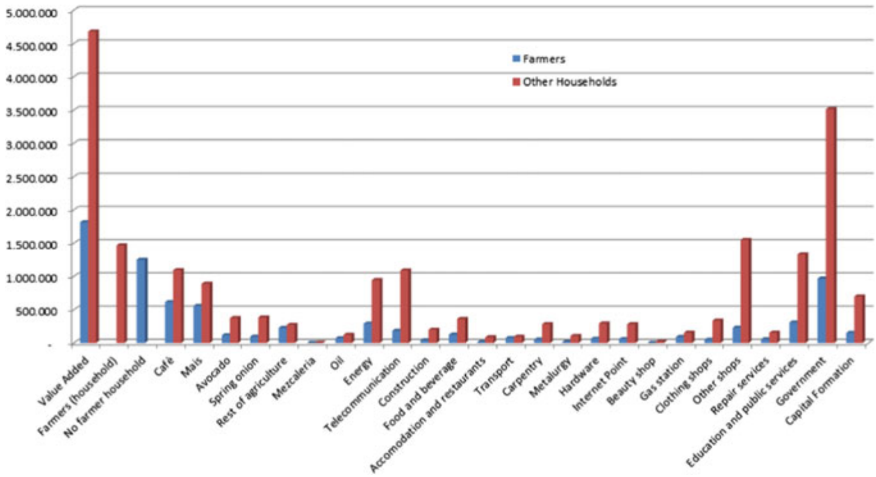


Fig. 6 Local impact of remittances

Table 6 Typical activities of a project with an ASAP component

Strengthening adaptive capacity of local institutions	Natural Buffer zones against climate extremes
Improving water resources	Livelihood diversification
Soil rehabilitation and protection	Improved processing and storage systems
Protection of communal infrastructure	Diversifying energy source
Climate information systems	Climate risk financing and transfer

contribution.[9] Programme investment and recurrent costs represent the expenditure vector[10] thanks to which we can estimate the short term impacts at both region and local level. The investment and recurrent costs considered in the analysis are: (i) Civil works; (ii) Goods and Supplies; (iii) Vehicles; (iv) Technical assistance; (v) Capacity building; (vi) Knowledge management; (vi) Salaries and Allowances.

The ASAP programme long term objectives represent the drivers upon which we have estimated the structural changes accrued to the targeted areas over a 10 years' time period after project implementation, vìs-á-vìs a traditional investment program lacking the ASAP component.

A typical project with an ASAP component consists of different activities and actions (Table 6).

In our investment project ASAP activities pertain to: (i) Strengthening adaptive capacity of local institutions; (ii) Improving water resources; (iii) Soil rehabilitation

[9]We calculated this amount as the average ASAP contribution to the IFAD investment portfolio in the year 2013/2014.

[10]Each expenditure item is classified accordingly to the SAM accounts and the NACE sector classification. The items are then reconciled and grouped as a vector.

Table 7 Investment and recurrent costs of alternative scenarios

	WP	WOP	WOP+
Labour	6.42	3.70	5.87
Agriculture	2.97	1.86	2.95
Forestry	4.95	4.00	6.35
Manufacturing	0.04	0.04	0.06
Construction	1.98	2.00	3.17
Social and personal services	3.65	1.00	1.59
Total	**20.00**	**12.60**	**20.00**

and protection; (iv) Natural Buffer zones against climate extremes; (v) Livelihood diversification.

Table 7 presents the investment and recurrent costs vectors related to three different scenarios:

1. ASAP (WP) for a total of 20 USD million;
2. Without (WOP) ASAP component for a total 12.60 USD million;
3. Without ASAP (WOP+) component for a total of 20 USD million.

Through these scenarios we would like to pursue a twofold objective of measuring short term incremental expected impacts on the economy, as the difference generated by two alternative projects (with and without ASAP), and simultaneously, to prove that the expected changes are not exclusively driven by budget amounts (Table 7).

4.1 Short Term Effects on the Oaxaca Region

4.1.1 A Direct Comparison Between WP and WOP

Estimates of the short term effects of the investment project on the Oaxaca economy are presented in Fig. 7. In the ASAP project scenario the results show an impact on value added equal to 50 USD million over an investment period of 5 years. In the WOP the value added impact is 30 USD million. In the production sectors the highest effect occurs in the Services account with a 43 USD million impact in the ASAP project and 25 USD million in the WOP (Fig. 8).

We can further analyse the different impacts on the productive sectors by dividing them into direct (expenditure) and indirect (multiplier) effects. In this specific investment scenario the sectors characterized by higher direct effects are associated with lower indirect effects. For instance, while on Agriculture and Forestry more than 40% of investment costs are spent, this initial spending accounts for only 19% of the total project impact (Fig. 10).

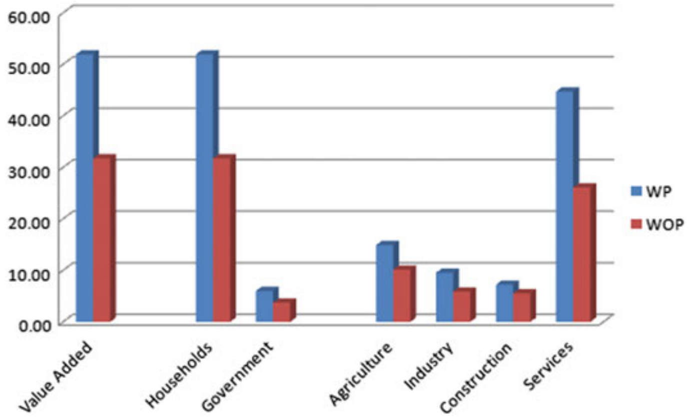


Fig. 7 Short term impact during investment period

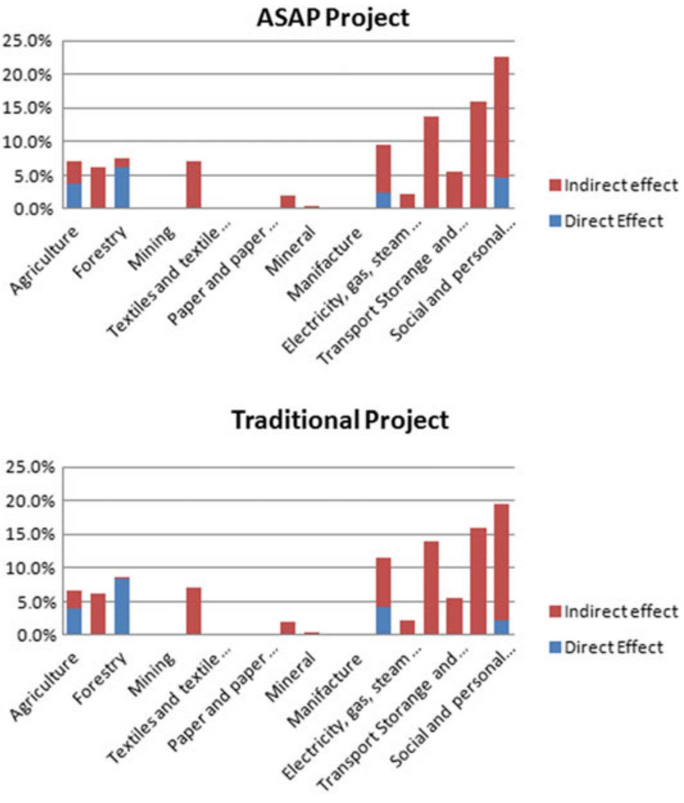


Fig. 8 Effects during the investment period in productive sectors

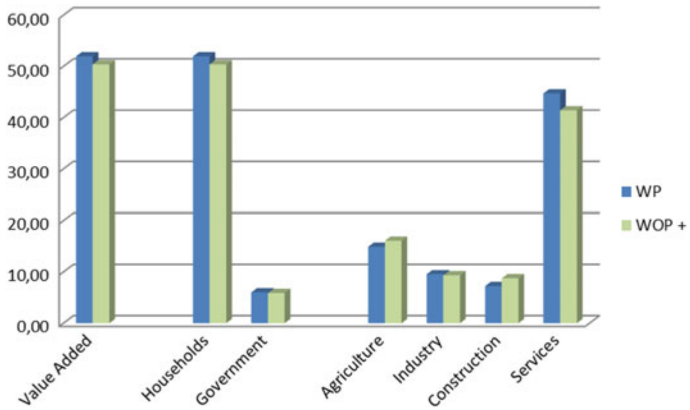


Fig. 9 Short term impact during investment period

4.1.2 A Direct Comparison Between WP and WOP+

Figure 9 shows the comparison between ASAP project (WP) and non-ASAP project (WOP+) for the same amount of resources.

In the ASAP project scenario the results indicate an impact on value added equal to 50 USD million over an investment period of 5 years. In the WOP+ scenario the value added impact is of about 49 USD million. In the productive sector the highest effect occurs in the Services account with a 43 USD million impact in the ASAP project and 41 USD million in WOP+.

In the midterm perspective, we consider production changes occurring in the sectors mainly affected by the programmes. The estimation is carried out over 10 years assuming an adoption timespan for the proposed interventions in line with what expected from the preliminary study of the project.

The likely effects on the Oaxaca State are measured as the difference between the development trends triggered after completion of the ASAP and non-ASAP project. In order to factor in the externalities related to climate change, we revised SAM's coefficients and multipliers, according with the Intergovernmental Panel on Climate Change (IPCC) long-term scenarios for the region[11] and the medium and long term OECD scenarios[12]. Table 8 summarizes the long term projections for Mexico.

The mid-term net effect, which is calculated as a cumulative difference of the two projects' trends, presents a growth pattern in Value Added and Natural sectors 15% higher for the ASAP *vis-à-vis* the non-ASAP, with a net gain for the Government of about 12% (Fig. 10).

[11]The IPCC scenario for Latin America are available at: http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=45.

[12]OECD Economic Outlook 2014.

Table 8 Mexico long term scenario (%)

	2014–2030	2031–2060
Potential GDP	2.9	3.2
Potential GDP per capita	2.0	2.9
Trend productivity	0.9	2.4
Potential employment ratio	1.0	0.5

Source Author elaboration on public data OECD 2014

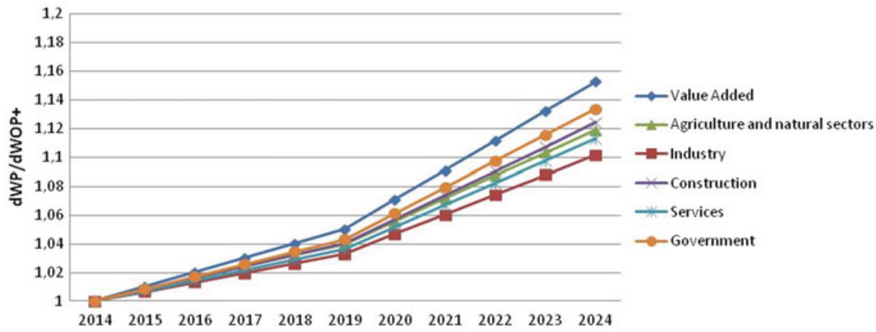


Fig. 10 Midterm growth difference in Oaxaca (WP—WOP+)

4.2 Impacts on the Local Economy

In order to downscale the analysis to the local level we reduced the expenditure vectors of the proposed projects, so as to estimate the share of project costs for each of the communities. Therefore, we assumed that 15% of total investment cost would be spent in the local economy. As shown in Fig. 11, in the short term the big bulk of the effects are concentrated in value added and agriculture sector. As mentioned in the previous section, the village rural economies in Oaxaca presented low level multipliers and the results on the short-term impact analysis confirms this characteristic.

During the five investment years, the ASAP project would generate and increase sector value added of about 5 USD million, 0.06 USD million more than the traditional project. In the productive sectors the impact would reach 8.17 USD million and 8.11 USD million respectively for the ASAP and the traditional project. The overall ASAP project impacts on the different sector determine a 31% increase on the local GDP.

The likely effects in the Oaxaca State are measured as the difference between the development trends triggered after completion of the ASAP and non-ASAP project. In order to factor in the externalities related to climate change, we revised SAM's coefficients and multipliers, according with the Intergovernmental Panel on Climate Change (IPCC) long-term scenarios for the region and the medium and long term

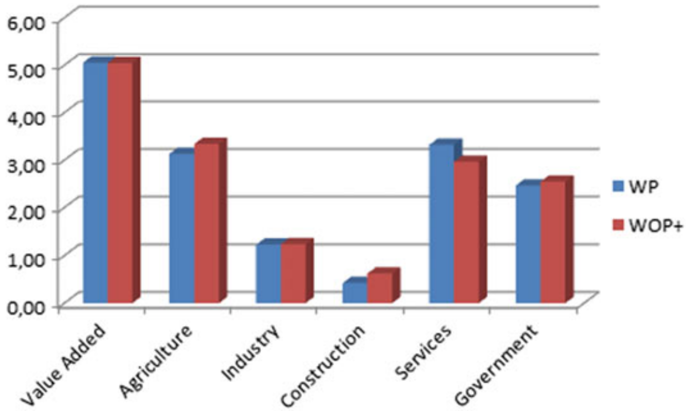


Fig. 11 Short term effect on local economy

OECD scenarios. For a more correct evaluation, we considered the different scenarios created after ASAP and non-ASAP implementation, within a nineteen year timeframe. The results show that in the standard project, production value of agriculture would increase of about 8% per year while the ASAP intervention would result in an increase of 12% per year.

These results notwithstanding, the most relevant results are foreseen in term of incomes of rural households. In fact, in the ASAP project their income would increase of 50% thanks to the knowledge acquired through the project on how to adapt to climate change. The following figures shows in summary the effect on Value Added, Households, Agriculture production, Industry, Construction, Services sectors and Government. The graphs depict the growth rates for each of the sectors with respect to the base year (Fig. 12).

5 Conclusions

The main objective of this study was to gain insights on whether, and under which conditions, a rural development project which includes Climate Change Adaptation strategies (as in the case of an ASAP investment) would trigger the economic growth in a region or in a group of villages.

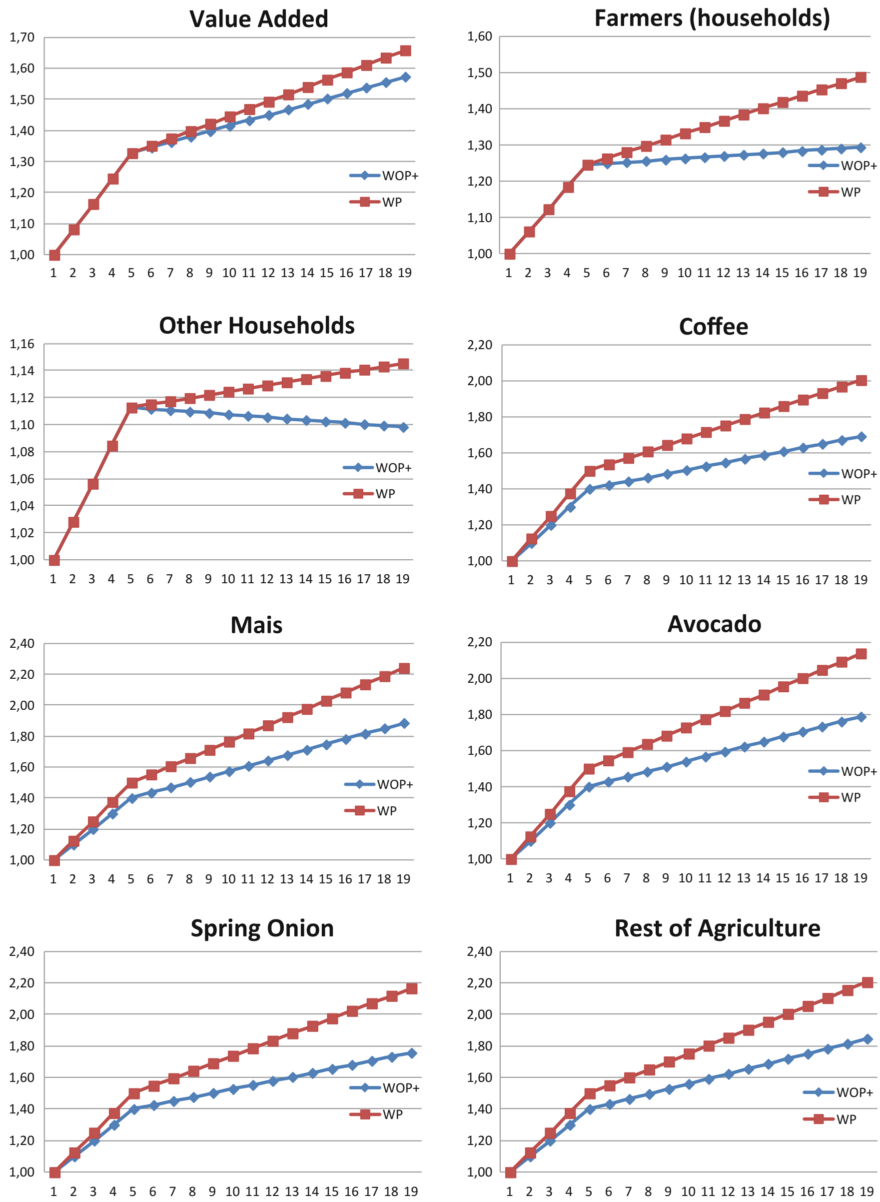


Fig. 12 Mid-term effect in local economy

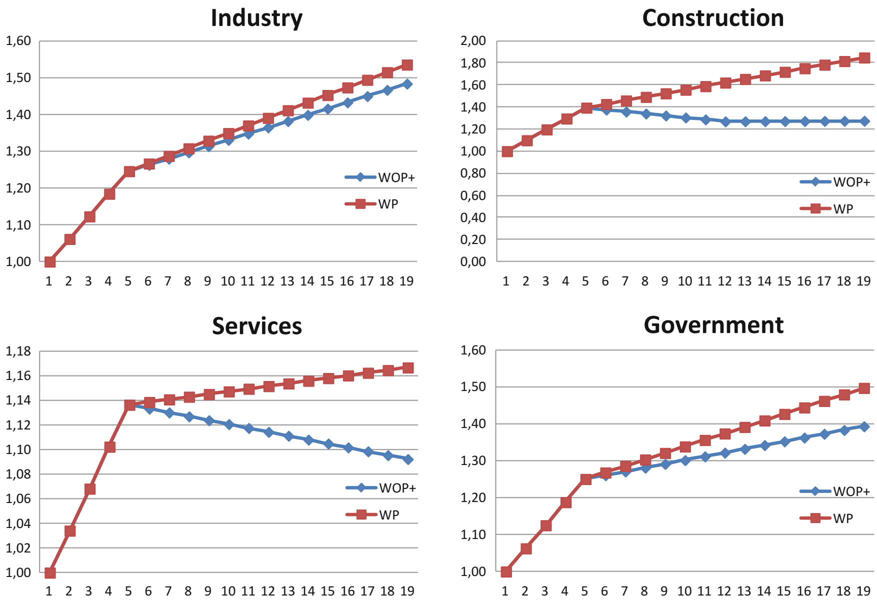


Fig. 12 (continued)

In particular, we applied an innovative methodology for estimating village-wide SAMs to make a direct comparison among three investment project scenarios (traditional investment project, ASAP project, and traditional investment project with total costs as ASAP project of reference). We therefore measure the extent to which a climate adaptation intervention would enable more stable paths of economic growth.

The geographic area under analysis is the district of Villa Alta in the region of the Sierra Norte, Oaxaca State (Mexico). In a first step of the analysis, we estimated the expected outcomes of the programmes in Oaxaca both in the short and medium term. In a second step, we develop a Village SAM to analyse the impacts of the three project scenarios at local level. Finally, we include a long term IPCC scenario to enhance the predictive capacity of our model over the medium–long range by factoring in climate change hazards for the region.

We believe that our results can usefully contribute evidence-based decisions on investments that aim to stimulate rural economic development and help develop strategies of adaptation to climate change. In the short term, we find some evidence of differences in impact between an ASAP and a traditional project, both regionally and locally. Differences however are smaller when we control for total project costs. Conversely, in the medium and long-term, the differences in impact between the scenarios are more evident, and could be explained in the light of the specific design features and components of a typical ASAP project and simulated through the changes in the SAM coefficients. ASAP projects in fact generally invest in strengthening relevant capacities and skills among the rural population, and thus can guarantee sustained growth even in the face of climate change phenomena. Indeed, thanks to the new knowledge acquired during the implementation of the project, farmers may apply new farming techniques, which in turn induce adaptive changes in the production structure of the local and regional agricultural sector. As results, farmers and the local, regional economies are better positioned to cope with climate change in the future.

Annex 1: Proposed Estimation Methodology for Village SAM (Scandizzo and Ferrarese 2015)

We propose to estimate the Village SAM with the methodology applied to the estimation of the system of regional social accounting matrices for Italy (Scandizzo 1993; Scandizzo et al. 2010). This methodology can be formalized as a problem of constrained maximization within the context of the generalized cross entropy (GCE) model proposed by Golan et al. (1996). In general terms, the estimation problem can be formulated as follows. Assume that a SAM is specified as a matrix of transactions between J sectors, factors and stakeholders. Consider each transaction (or, in normalized form, each coefficient) b_{ij} as the expected value of a random variable with support $[z_1, z_2, \ldots z_M]$ and probabilities $[p_{1ij}, p_{2ij}, \ldots p_{Mij}]$. The support values indicate the range of possible values for each coefficient. Since the SAM coefficients are shares of column totals, the interval of these values is comprised between 0 and 1. The corresponding range of the support values may be constituted, in the interval considered, by a discrete series of values or by a continuum. For simplicity, we assume that the first hypothesis holds and that it is possible to specify the same set of possible, but not equally probable, values M for each coefficient. Given a set of prior estimates q_{mij} of the probabilities associated to the possible values of each coefficient, posterior estimates can be obtained by solving the problem:

$$\max_{p_{mij} \geq 0} H = -\sum_m \sum_i \sum_j p_{mij} \log \frac{p_{mij}}{q_{mij}} \tag{1}$$

Under the constraints:

$$\sum_m p_{mij} = 1 \tag{2}$$

$$\sum_i \sum_m p_{mij} z_m = 1 \tag{3}$$

$$\sum_j \sum_m p_{mij} z_m v_{*j} = v_{i*} \tag{4}$$

where v_{*j} is the vector of the pre-defined column totals and v_{i*} the vector of the pre-defined row totals.

The objective function in (1) which is typically denoted as "cross entropy", in reality is not an entropy indicator, but the sum of the entropy measures, according with Shannon's definition (19448) for each column of the matrix and for each element of the probabilistic support $[z_1, z_2, \ldots z_m]$. More precisely, we can define as column entropy level for the m-th state of nature the function $H_{jm} = -\sum_i p_{mij} \log p_{mij}$. This function measures the quantity of information contained in the probability of each column for each state of nature as the logarithmic difference of the uniform distribution. When information is constituted only by the constraint that the probability sum must equal 1, the entropy is at a maximum, and the best estimate of the probabilities of the j-th column is that they are all equal to $1/M$. The entropy indicator thus measures the additional degree of information with respect to an informed prior distribution. If the analyst possesses a more informed prior, for example in the form of a prior probability q_{mij}, this can be incorporated in the logarithmic term of the entropy measure:

$$H_{jm} = -\sum_i p_{mij} \log \frac{p_{mij}}{q_{mij}} \tag{5}$$

Given a SAM, it will thus be possible to specify a different measure of entropy for each column (or each row) or even each value of the stochastic support z_m. The "cross entropy" is the sum of these row or column entropies and represents, not itself an entropy, but only one possible synthetic index of the entropy that can be associated to the SAM's rows and columns. Instead of a simple sum, in particular other weighting schemes can be used to reflect the different value that can be attributed to the information contained in a SAM according with the size or the variability of the flows, their statistical reliability and other special properties one may wish to consider.

Going back to the problem (1)–(4), the estimation of the coefficients b_{ij} is given by:

$$b_{ij} = \sum_m p_{mij} z_m$$

The corresponding Lagrangean is:

$$L = -\sum_m \sum_i \sum_j p_{mij} \log \frac{p_{mij}}{q_{mij}} \tag{6}$$

$$-\sum_i \sum_j \gamma_{ij} \Big(\sum_m p_{ijm} - 1\Big) - \sum_j \lambda_j \Big(\sum_i \sum_m p_{mij} z_m - 1\Big) - \sum_i \mu_i \Big(\sum_j \sum_m p_{mij} z_m v_{*j} - v_{i*}\Big) = 0$$

The Kuhn Tucker conditions for the solution of the problem (1)–(4), are given by the constraints (2), (4), assuming that they are binding and by the following expressions:

$$\begin{aligned}&\tfrac{\partial L}{\partial p_{mij}} = \log \tfrac{p_{mij}}{q_{mij}} + 1 + \gamma_{ij} z_m + \lambda_{ij} z_m + \mu_i v_{*j} z_m \\ &m = 1, 2 \ldots M; \; i = 1, 2 \ldots I; \; j = 1, 2 \ldots J\end{aligned} \quad \text{or} \quad p_{mij} = 0 \tag{7}$$

Solving for p_{mij}:

$$p_{mij} = q_{mij} \exp(-1 - \gamma_{ij} z_m - \lambda_j z_m - \mu_i z_m v_{*i}) \tag{8}$$

Summing over m, we obtain:

$$\sum_m p_{mij} = 1 = \sum_m q_{mij} [\exp(-1 - \sum_m \gamma_{ij} z_m - \sum_m \lambda_j z_m - \sum_m \sum_j \mu_i z_m v_{*j})]$$
$$\sum_m p_{mij} = 1 = \sum_m q_{mij} [\exp(-1 - \gamma_{ij} z_m - \lambda_j z_m - \mu_i z_m v_{*i}] \tag{9}$$

Implying:

$$\exp(1) = \sum_m q_{mij} [\exp(-\gamma_{ij} z_m - \lambda_j z_m - \mu_i z_m v_{*i}] \tag{10}$$

And, substituting in (8):

$$p_{mij} = q_{mij} \exp[-z_m(\gamma_{ij} + \lambda_j + \mu_i v_{*i})] / \sum_m q_{mij} \exp[-z_m(\gamma_{ij} + \lambda_j + \mu_i v_{*i})] \tag{11}$$

From (11) one can derive the estimate of a distribution of m matrices of $I \times J$ coefficients which are function of a prior value of the probabilities and the constraints' shadow prices:

$$b_{mij} = p_{mij} z_m = \frac{q_{mij} z_m [\exp(-(\gamma_{ij} + \lambda_j + \mu_i v_{*i}) z_m)]}{\sum_m q_{mij} [\exp(-(\gamma_{ij} + \lambda_j + \mu_i v_{*i}) z_m)]} \tag{12}$$

With expected values:

$$b_{ij} = \sum_m p_{mij} z_m = \frac{\sum_m q_{mij} z_m [\exp(-(\gamma_{ij} + \lambda_j + \mu_i v_{*i}) z_m)]}{\sum_m q_{mij} [\exp(-(\gamma_{ij} + \lambda_j + \mu_i v_{*i}) z_m)]} \tag{13}$$

In our experience a prior distribution q_{mij} may be typically characterized as a normal distribution with mean and variance equal to:

$$b^0_{ij} = E b^0_{mij} = \sum_m q_{mij} z_m, \quad i = 1, 2 \ldots I, \quad j = 1, 2 \ldots J \tag{14}$$

$$Var(b) = E \left\| b^0_{mij} - b^0_{ij} \right\| \tag{15}$$

This prior distribution is the distribution of non-balanced matrices derived from direct estimates of the totals from aggregating survey data, or using time series. The estimate proposed by Eq. (13), even though based on a constrained maximization, can be computed using a stochastic simulation and an iterative algorithm of the RAS type that re-proportions iteratively the columns and the rows of the matrix to estimate: The estimate can in fact be interpreted as an adaptation of an initial estimate proportional to a function of the expected value of the variable $x_{mij} = z_m \exp(-\gamma_{ij})$, to make this variable satisfy the constraints given by the sums of the rows and the columns.

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