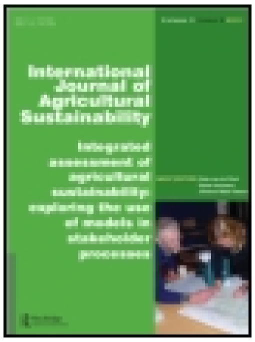

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Why do medium- and large-scale farmers succeed practicing CA and small-scale farmers often do not? – experiences from Paraguay

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Why do medium- and large-scale farmers succeed practicing CA and small-scale farmers often do not? – experiences from Paraguay

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Conservation agriculture (CA) is defined as a system comprising no or minimum mechanical soil disturbance, permanent organic soil cover, and crop species diversification [FAO. (2014). What is Conservation Agriculture? FAO CA website, consulted on 15.09.2014. Retrieved September 15, 2014, from http://www.fao.org/ag/ca/1a.html]. The vast majority of medium- and large-scale farmers in Paraguay and neighbouring countries (Argentina, Brazil, and Uruguay) who use tractor-based farming systems have moved from conventional agriculture and adopted CA through no-tillage technologies. Among this farmer type, very few wish to return to the old system of tillage agriculture. However, despite massive efforts to transmit the technology to small-scale farmers by development aid projects and local governments, widespread adoption of CA has not happened on farms that use animal traction or manual farming systems; in fact significant dis-adoption of CA practices by smallholders has occurred. Some of the reasons for this dynamic are analysed in this paper. The reasons for dis-adoption by small-scale farmers can be generally divided into two groups. One group has to do with the fact that, comparatively, small-scale farmers are less able to cope with the factors related to CA (e.g. degraded soils, recuperating and maintaining soil fertility and know-how) than medium- and large-scale farmers. The second group of reasons has to do with the approaches and strategies that development aid agencies and local governments have taken towards small-scale farmers, which have influenced small-scale farmers' ability to adopt and maintain CA practices. Small-scale farmers' main asset is the soil and the CA/no-tillage system is a knowledge-based, learning-intensive system. However, despite the technical support provided by aid agencies and local governments, small-scale farmers often lack a deeper understanding of the CA concepts and practices. This is attributable to the short- to medium-term and rather conservative transfer-of-technology approaches that have been applied by development aid agency and local government programmes over the years, without any changes and without adaptive research. The latter can be derived, for instance, from the accountability of results to donor agencies or the one-size-fits-all approach applied in order to achieve 'numbers'. One consequence of this is that ownership by and empowerment of farmers is often absent among dis-adopters. It therefore seems more suitable to apply long term, adaptable approaches to CA with smallholders. The lessons learned in Paraguay may well serve to properly direct future development intervention efforts in this country and also serve to mend development strategies in other countries in South and Central America, Africa or Asia.

Keywords: conservation agriculture; no-tillage; reasons for technology dis-adoption; small-scale farmers; development strategies

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1. Introduction

Intensive crop production based on tillage agriculture cannot meet the challenges of the new millennium. This is because it degrades the soil and reduces its productive capacity (Kassam, Derpsch, & Friedrich, 2014). Tillage agriculture constantly reduces organic matter content of the soil which has a direct correlation with soil quality and soil productive capacity (Sá et al., 2013). Conservation agriculture (CA), defined as a system comprising no or minimum mechanical soil disturbance, permanent organic soil cover, and crop species diversification (FAO, 2014), has gained worldwide popularity due to the fact that it mitigates declining soil fertility, among other things. The social, economic, and environmental advantages of CA, in addition to improved soil productivity and resilience, benefit large-, medium- and small-scale farmers in a similar way. However, the massive adoption rates achieved in tractor mechanized farming systems in the world, in South America (Argentina, Brazil, and Uruguay), and specifically in Paraguay (CA adoption rate >90%), have not been achieved in animal traction or manual production systems. For example, in Brazil, many animal traction farmers who practised no-tillage have bought a tractor or have their mechanized neighbours seed their crops with their tractor-driven no-till equipment.

Concerted efforts from international donors in Paraguay (GIZ, KfW, World Bank, IDB, and USAID) and the Paraguayan government, through the Ministry of Agriculture and Livestock (MAG), to spread the system among smallholders have been effective as long as technical assistance and incentives were delivered to the farmers; the MAG/GIZ/KfW efforts particularly followed a rigid market approach to CA as e.g. Corbeels et al. (2014) had suggested. However, once the donor or government support ceased, a significant dis-adoption process took place among small-scale farmers. It has been observed that among those farmers who have been trained in the CA/no-till system by different projects[1] only about half of them are still practising the no-tillage system and use green manure cover crops (gmcc) on their farms in 2014.

A first evaluation of adoption rates was carried out in 2010, after a German-supported project to promote CA/no-till at the small-scale producer level in five departments in the northern region of Paraguay (Froemherz-Rivas, 2010). The study revealed that nearly 100% of the 15,174 farm families benefiting from this project had adopted CA on a total area of 12,746 ha during project implementation. At the same time, neighbour-farmers with similar socio-economic conditions who were not beneficiaries of the project (149,000 farm families) had adopted CA technologies at only a 6% level, indicating a very low distribution effect in the absence of targeted extension efforts and input supplies (Froemherz-Rivas, 2010). One year after finalizing the project, the former adoption rate of the project beneficiaries in this region dropped from 100% to 55% (Ruiz Díaz, 2012). In a separate study, the adoption rate of CA practised by 8974 small-scale producers assisted by the national extension service over several years was revealed to be only 16% on 718 ha. The average CA area per farmer was calculated at a meagre 0.08 ha. (GIZ, 2014). In light of all this evidence, it is pertinent to analyse the reasons why this dis-adoption has happened and is still happening.

This article is based on more than 20 years of experience by the authors in Paraguay, as well as available publications on CA and other development interventions implemented in this country. In order to identify causal factors for the high dis-adoption rates of CA with small-scale farmers, which is in stark contrast to the mechanized farming sector, this paper is divided into three parts. The first part looks at the natural (climate and soil), social, and economic factors (farming systems and the economic importance of agriculture for the country) related to crop production in Eastern Paraguay.[2] The second part of the article looks at comparative reasons for the dis-adoption of CA by tractor-mechanized farming systems (usually run by medium- and large-scale famers) and small-scale farmers. In the third part, the authors of this paper analyse some reasons for the dis-adoption of CA that are specific to the small-scale farmer level in Paraguay.

2. The natural, social, and economic factors of Paraguayan farming systems

The production of crops and with it the utilization of CA for crop production is almost entirely confined to Eastern Paraguay. The climate is favourable for agriculture; where the mean annual rainfall is 1700 mm. The continental, mainly subtropical climate generates high mean annual temperatures, from 19.8°C in the southeast to up to 25.9°C in the northern area. Two main seasons can be distinguished in Eastern Paraguay; a mild winter where frosts sporadically occur in the southeast, and a hot, moist summer where in most parts of the country the rainfall rate is significantly higher than in winter (Glatzle & Stosiek, 2006). These climactic conditions allow for two annual crop cycles, one in summer and one in winter, an important point for the application of crop rotations in CA.

Eastern Paraguay can be divided into two regions according to soil type. The first region consists mainly of acrisols, planosols, nitrosolos, and fluvisols, all generally sandier soils. They have a clay content of 10–35% and are suitable for crop production (Florentín, Peñalva, Calegari, & Derpsch, 2001). The second region consists of mainly ferrosols and nitrosols, which have a clay content of 35–60% and a high content of soil organic matter. Until the 1990s these soils were covered with primary forest and were very good for crop production (Van Der Glas, 1998). However, due to the clearing of these forest areas and their use for crop production, the soil organic matter declines after a few years of tillage agriculture resulting in the need to apply chemical fertilizer to maintain production (Riezebos & Loerts, 1998).

According to Dixon, Guliver, and Gibbon (2001) the farming systems in Paraguay belong to the cereal-livestock classification (Campos). However, two distinct agricultural production systems can be identified. The first system comprises the majority of Paraguayan farmers (approx. 240,000 farm families), who are subsistence smallholders which, according to the MAG, can be characterized as farms of less than 20 ha. While not all of this land is dedicated to production, the parts that are either worked by hand or with draught animals, are mainly used for personal food consumption and additional income through limited surplus production. The main food crops grown are maize (*Zea mays*), cowpeas (*Vigna unguiculata*), sugarcane (*Saccharum officinarum*), cassava (*Manihot esculenta Crantz*), and peanuts (*Arachis hypogaea*). Additionally, some farmers have a small vegetable garden and some animals (e.g. limited number of cattle, chickens, pigs, etc.). The intensification and diversification of smallholders' production systems in general are rather low. For many years, cotton (*Gossypium hirsutum*) was the main source of income and was the traditional cash crop of Paraguayan smallholders (Lange & Moriya, 2004), but declined in significance due to increasing soil degradation.

The second production system comprises medium–large and large-scale farmers (>20 ha). These farms are tractor-mechanized, produce mainly for export, and are mostly under CA (Duarte & Kawamura, 2002). The main crop grown is soybean (*Glycine max*) (primarily for export), but there is also wheat (*Triticum aestivum*), maize, or sunflower (*Helianthus annuus*), planted in rotation with soybean, made possible by the two annual crop cycles previously mentioned. Recently, due to the increasing use of CA, black oats (*Avena strigosa)* (occasionally in association with white lupines (*Lupinus albus)* and oilseed radish (*Raphanus sativus var. oleiferus*)) are planted as gmcc, either in rotation or in plant associations. These farmers use chemical fertilizers and agro-chemicals to manage weeds and pests. Moreover, the utilization of Precision Agriculture has increased on these farms (Duarte & Kawamura, 2002). The main production areas for this system are found on the eastern edge of eastern Paraguay – the Paraná basin – which was originally covered by the Atlantic forest. This region is characterized by good infrastructure (e.g. silos, machinery vendors, input suppliers, private extension services) and a good trading network, mainly attributable to the fact that production cooperatives, to which many of the mechanized farmers belong, are widely spread in this region (Masi, Penner, & Dietze, 2000).

According to Dietze (2012) and Teicher (2014), the agricultural and forestry sector generates 27% of the national gross domestic product (GDP), provides 24% of direct employment, and contributes 80% to the national exports (excluding electric power). However, within the export sector there has been a major shift in contribution. Whereas in the beginning of the 1990s, cotton was the most important crop, comprising almost 35% of total exports, which, as mentioned before, was the main source of income for smallholders, after 1995, soybean has developed into the most important export crop. Today, soybean contributes to 43% of Paraguay's exports, and cotton has decreased to less than 5%. Dietze (2012) stresses that 57% of the Paraguayan economy (in terms of GDP including agribusiness) depends on the primary sector and 60% of employment is allocated to the primary and related sectors.

The importance of soybean can be seen when the total share of worldwide production is considered. Paraguay has become the world's sixth largest soybean producer and the fourth largest exporter (Teicher, 2014). Given that soybean is the main crop produced by tractor-mechanized farmers under CA, it appears that the results of this increase of importance could also have caused an increasing disparity between mechanized and small-scale farmers in Paraguay.

3. Some reasons for dis-adoption of CA by small-scale farmers that are comparable to medium- and large-scale farmers in Paraguay

3.1. *Problems with small-scale farmers' main asset, the soil*

3.1.1. *Prevalence of degraded soils*

Small-scale farmers tend to have more degraded soils than medium- and large-scale farmers, because small-scale framers generally cannot afford fertilizer and lime, or they are not available in remote areas, resulting in their infrequent application. The consequence is soil mining because farmers are extracting and exporting nutrients through the harvesting process, which are then not replaced. Additionally, nutrients are exported by water erosion.

Studies conducted by Villalba on sandy soils in the Province of San Pedro, and published by Florentín et al. (2001), showed a huge decline in organic matter and mineral content (Ca, Mg, and P) in soils with only 15 years of ploughing in smallholder production systems. In this short period of time, organic matter content was reduced from 2.44% to 0.81%.

It is obvious that it takes much more time to recuperate the fertility (chemical, physical, and biological) of extremely degraded soils than less degraded soils. In the initial phase of CA adoption, crops may yield less (Derpsch, Florentín, & Moriya, 2000) than in a conventionally cultivated system (where tillage releases Nitrogen) due to soil degradation (low fertility), which could be a reason why smallholders end up rejecting the new technology.

In the case of extremely degraded soils, without structure and in drier conditions, the use of ripping tines for deep loosening of the planting rows along with high disturbance chisel-type no-till planters had been recommended in the early years of CA adoption in Paraguay. It was recommended that this could be accompanied by the planting of some deep rooting crops to stabilize the soil. After several years of this practice, and depending on the conditions of the soil, the adoption of low disturbance no-till practices and crop rotations could be added, and a profitable permanent CA/no-tillage system could be implemented (Derpsch et al., 2014).

3.1.2. *Difficulties in the recuperation of degraded soils*

One necessary condition for the recuperation of degraded soils is that a minimum of plant biomass (i.e. 8–10 t/ha under the climatic conditions of Paraguay and Southern Brazil) needs to be returned to the soil each year (Derpsch et al., 2014). If we want to rehabilitate the fertility of extremely degraded soils, this quantity needs to be even higher. Without fertilizer, it will be very difficult to produce the high amounts of residues needed for the restoration of soil fertility in an acceptable lapse of time. Therefore, fertilizers will need to be applied to be able to produce the biomass necessary for soil rehabilitation. Additionally, high biomass-yielding rustic gmcc need to be incorporated into the rotation. But how can this be achieved by small-scale farmers who do not have the resources to buy fertilizers, or have difficulties in accessing gmcc seeds, or where credits and loans are not always available? Additionally, in Paraguay there is the problem of competition with animals feeding on plant residues, which hinders the return of sufficient plant biomass to the soil. In contrast, medium- and large-scale farmers are able to apply chemical fertilizers and lime, and restore their soils. Access to credit and loans are also easier for those types of farmers, especially when they are members of a cooperative.

3.1.3. *Inability of small-scale farmers to provide crops the necessary nutrients*

While most medium- and large-scale farmers monitor their soil fertility through regular soil analysis, this is seldom the case with small-scale farmers. In Paraguay and Brazil, soils that have not been corrected typically lack phosphorus and calcium and may also have low pH. Organic matter is also often very low. We know that without humus, calcium, and phosphorus plants cannot adequately grow and yield sufficient plant biomass and grains at harvest. As stated before, rehabilitation of degraded soils can only happen when adequate amounts of biomass are returned to the soil and basic nutrients have been added so that soils have a balanced nutrient and pH status. It also needs to be considered that more N is needed in no-tillage systems in the initial phase, the provision of which requires the availability of cash. As mentioned above, money as well as loans to buy fertilizers is frequently not available, or small-scale farmers are not willing to spend money for fertilizers because they are too expensive. It has also been observed that when fertilizers are provided free of cost by development projects, farmers often prefer to sell the fertilizer, or parts of it, to get cash instead of applying it to their fields for crop and soil improvement. This of course is not in the interest of donors and actually not in the medium- to long-term interest of famers, either.

The importance of using fertilizer to enhance crop productivity and organic residue availability has been highlighted by Vanlauwe et al. (2014). The authors of this paper go as far to claim that 'The appropriate use of fertilizer to enhance crop productivity' is required as a fourth principle to define CA in sub-Saharan Africa to increase the likelihood of success of CA and benefits for smallholders. The authors emphasize that proper nutrient management is decisive in sustaining agricultural production. On the other hand, although recognizing the importance of proper nutrient management, in response to the cited paper, Sommer et al. (2014) contend that, 'Fertilizer use should not be a fourth principle to define Conservation Agriculture'. Sommer and co-authors strongly agree that fertilizer application (organic or inorganic) is crucial to make CA work. They state that adequate nutrient management is a sound agronomic praxis in CA as well as in any production system, but it is not a principle, instead it should continue to be considered as praxis. The authors of this paper support the arguments by Sommer et al. (2014). It should also be considered that in Paraguay 53% of farmers with up to 20 ha are below the extreme poverty line, which means that they are struggling to feed and dress themselves and educate their children. How could they afford to buy fertilizer?

3.1.4. *Exploding land and commodity prices*

The promotion of biofuels by industrialized countries has led to an explosion of land and commodity prices. This again has led to a situation where small-scale farmers are often tempted to sell their land to neighbouring medium- and large-scale soybean farmers who pay values a small-scale farmer never dreamed of possessing. Why should a farmer care for his land and conserve it, when he might sell it for a large sum to his neighbour in the near future?

3.2. *Know-how and related issues linked to CA adoption*

3.2.1. *Conservation Agriculture is a knowledge-intensive system*

Farmers need to be aware of the evolution of a long-term CA/no-till system. The transition from conventional to a CA/no-till system normally takes place in four distinct phases over several years (Sá, 2004).

In the *initial phase* (0–5 *years*), the soil starts rebuilding aggregates and recomposing micro- and macro-biological activity. Crop residues are low and N needs to be added to the system.

In the *transition phase* (5–10 *years*) an increase in soil density is observed. The amount of crop residues as well as carbon content and phosphorus content start to increase.

In the *consolidation phase* (10–20 *years*) higher amounts of crop residues as well as higher carbon contents are achieved, and a higher cation exchange capacity and water holding capacity are measured. Greater water-holding capacity and nutrient cycling are also observed.

In the *maintenance phase* (>20 *years of continuous no-till*) the ideal situation with the maximum benefits for the soil and crops is achieved and less fertilizer is needed. ***Farmers need to be aware that any tillage performed in phases 2 to 4 means a return to the initial phase, i.e. to start with CA from anew.***

3.2.2. *The praxis of rotational tillage*

While the vast majority of medium- and large-scale farmers practice a permanent CA/no-till system in South America, most small-scale farmers (the same as many commercial farmers in the USA and some other regions) rotate between tillage and no-tillage phases. It has been shown that under rotational tillage farmers will never get to reap all the benefits of a CA/no-till system. Under rotational tillage the soil may reach the transition phase but will never get to the consolidation phase.

3.2.3. *Lack of understanding and ability on how to maintain soil fertility over time*

It has been said that at least 8–10 t/ha of dry matter of harvest residues or gmcc need to be returned to the soil (biologically) each year in a no-till system under prevailing soil and climate conditions in Paraguay and Southern Brazil (Derpsch et al., 2014), if fertility and the vital organic matter of the soil are to be maintained and sustainable agricultural production is to be achieved. Not only due to the lack of financial means, but also due to the lack of understanding regarding how to maintain soil fertility, small-scale farmers seldom reach this level of year-to-year biomass return although soil and climate conditions are conducive to meet this goal relatively easily (e.g. maize – tropical cover crop system). But a vicious circle of low input (nutrient depletion) – low yield – low biomass return (increased soil degradation) – low economic return, is the harsh reality for small-scale farmers here and in most regions of the world (FAO, 1994; McCown & Jones, 1992; Steiner, 1994). In other words, many small-scale farmers are caught in 'the downward spiral of the poverty trap' from which it is extremely difficult to escape by only one's own efforts.

3.2.4. *Lack of understanding of the importance of soil cover*

Surface residue cover is a key feature of CA systems especially on small farms. We need to remember that almost all advantages of the no-till system come from a permanent cover of the soil and only few from not tilling the soil. Research by CIMMYT in Bolivia (Wall, 1999) and Mexico (Sayre, Govaerts, Martinez, Mezzalama, & Martinez, 2006) has shown that removing residues to sell them will lead to drastically reduced yields and lower economic returns, when compared to retaining all residues on the soil surface in a no-tillage system. But crop residues are often removed by small-scale farmers to feed their cattle or for other purposes, which might contribute to the dis-adoption of CA by those farmers. Consequently, a better understanding of the importance of soil cover needs to be achieved among small-scale farmers. The experience of some small-scale farmers, who achieved the integration of crop- and livestock systems, indicated that in this case the removal of soil cover stops and CA systems prevail (M. Villalba, pers. comm.).

In contrast, the medium- and large-scale farmers have continuous technical support by cooperatives or by technical staff of input companies, which leads to a better understanding of the importance of soil cover and, consequently, these farmers do have permanent organic soil cover on their farms.

3.2.5. *Lack of understanding of the importance of green manure cover crops*

Green manure cover crops are of utmost importance for small-scale farmers to be able to suffocate and control weeds by producing a sufficient amount of mulch (permanent organic soil cover). Instead of buying expensive herbicides, small-scale farmers can suffocate weeds by an adequate selection and timely seeding of gmcc. Using these, they can reap the benefits of crop rotation and at the same time supply nutrients, especially Nitrogen, to the subsequent food or cash crops. They are also crucial for adding biomass and increase the organic matter content of the soil as well as protect the soil against erosion. Gmccs are a key element to be able to achieve agricultural sustainability on small farms. Their use in praxis is often hindered because of a lack of seeds, low-quality seeds, and other bottlenecks. Contrary to this, commercial farmers have access to quality seeds and plant gmccs; they often even harvest gmccs seeds, which provides for additional income.

3.2.6. *Incapability to deal with weather challenges*

Drought in crucial phases of crop and/or gmcc growth results in poor biomass production of crops and insufficient soil cover. Poor biomass production may result in the inability of cash and/or gmccs to suffocate weeds and supply enough nitrogen to the next crop. Therefore, poor weed control may hinder crop growth and lead to low biomass and yield of cash crops, which further hinders the recuperation of degraded soils. Mechanized farmers are better equipped and generally have the means, e.g. crop insurance, to quickly overcome unfavourable weather challenges.

4. Some reasons for dis-adoption of CA by small-scale farmers in Paraguay that are not comparable to medium- and large-scale farmers: problems of development aid approaches

4.1. *Provision of inadequate technical and extension approaches*

The development aid approaches used in Paraguay are neither economically attractive nor are they accessible for most small-scale producers that are not part of development interventions. While programmes and projects promoted the same CA technology for small-scale farmers during the last two decades without significant changes, following a top-down, transfer-of-technology approach, neither research nor adaptive research on these programmes have been carried out during this time.

4.2. *Lack of continuity of development projects and technical assistance*

Introducing CA/no-till into a region will necessitate continued technical (and maybe financial) support over a period of at least 10 years until the system is solidly established and the consolidation phase is reached so that dis-adoption is less likely to happen. Unfortunately, development projects virtually never last that long and local extension services in countries like Paraguay lack the necessary support consisting of well-trained, up-to-date extensionists, well-maintained vehicles, fuel, and/or daily allowances to reach every corner of the country. The rule more often is that official extension services reach only a small portion of small-scale farmers, which in Paraguay is not surprising, given the sheer number of smallholders in this country (approximately 240,000 in the range of 1 to 20 ha according to the census of 2008). Again this is not the case for medium- and large-scale farmers. Their membership in cooperatives and the support by agricultural input and machinery companies provides for continued technical support and allows them to reach the consolidation phase with relative ease.

4.3. *The counterproductive praxis of development projects of donations*

Experience has shown that if subsidies are given to small-scale farmers in the form of donations to encourage adoption of technologies and/or soil conservation practices, farmers will follow recommendations as long as they receive these donations, but will discontinue once subsidies cease. Good examples are the projects PMRN, PAGRO, and PRODERS in Paraguay, financed by KfW, IDB, and WB, where donations in the form of equipment, fertilizer, and seeds were given to farmers who were willing to adopt CA. Farmers accepted the project because of the incentives they received, but were not convinced of the technological approach because they did not believe in the new technology as the period of technical assistance was too short and mostly focused on the transfer of technology instead of creating ownership/empowerment of farmers, and the learning aspect of CA required by the amount of new information that farmers had to 'digest'. Likewise, accompanying topics such as farm economics, general ecological aspects, and long-term farm planning were often not part of the development interventions. In other words, very often development projects did not have the appropriate strategy for a long-term sustainable approach to CA.

4.4. *Untimely release of funds to support small-scale farmers*

Development projects in Paraguay that have promoted CA have been compelled by the government to channel funds via the Ministry of Finance which means an endless and complicated bureaucracy to have the funds released before they reach small-scale farmers. This resulted in untimely implementation of farming operations like seeding cash crops, seeding gmcc, fertilizing or liming the fields, etc. because inputs could not be delivered to farmers in a timely manner. Everybody involved in practical farming knows that timely implementation of each and every farm operation is absolutely fundamental for success. In contrast, untimely performance of farming activities will result in poor development of crops and gmcc, leading to high weed infestation, poor yields, and meagre economic returns. Under these circumstances, farmers will never get to enjoy a feeling of success with the implementation of new technologies, in this case CA. The dis-adoption of the new technology is likely to be the consequence.

4.5. *Low quality of machines for CA*

If equipment is bought in development projects as well as in the MAG in Paraguay or elsewhere, these have to go through a tender process and the lowest offer has to be accepted. Only in exceptional cases there is a way around this regulation. This has led to a situation where the cheapest equipment offered in the market is bought without considering quality standards. To meet the rising demand for CA equipment, many small industries have emerged, which in principle is good, but all too often has resulted in the provision of low-quality equipment which breaks down or does not work properly after a short time. This leads to a discontinuation of CA practices on these farms. As a consequence, a considerable number of machines bought with development aid money are rusting away on small farms and can only be used after costly repairs or sold as old iron.

4.6. *Inadequate development intervention strategies*

Lavagnon (2012) asserts that many projects 'fall into one of four main traps: the one-size-fits-all technical trap, the accountability-for-results trap, the lack-of-project-management-capacity trap, and the cultural trap'. Development projects should pay attention to these issues in the planning and execution phases. Projects also should reflect on understanding why farmers are rejecting or dis-adopting a technology. In essence, are farmers unable, unwilling, or both? (Nowak, 1992). Among the reasons why a farmer might be unable to adopt a new technology, Novak cites that the complexity of the system might be too great, that the planning horizon might be too short, or that inadequate managerial skills lead to failure. Belief in traditional practices, information conflicts, or conflicts between current production goals and the new technology might be reasons why a farmer is unwilling to adopt (Nowak, 1992). This was also the case in Paraguay where many of the development interventions were required by their own project objectives to achieve numbers, which had to be reported to donors on time. This led to rejecting a more time-consuming individual approach to CA by smallholders or farmer groups, instead adopting a one-size-fits-all transfer-of-technology approach. In cases where extensionists partnered with farmers, as in the case of a CA farmer group in Edelira, considering the individuality of each farmer and his farming system, the continuation of CA has been achieved (Lange, 2005). The underlying condition for this to happen is to offer farmers a basket of options from which to choose, recombine, and reinvent solutions suited to their individual ability and interest, according to their environment and socio-economic situation.

4.7. *Inadequate service systems for agricultural development*

Agricultural and rural development requires a functional local or regional service system. Development only occurs if research, extension, credit, input supply, and markets are functioning in a timely, opportune, and synchronized way. Neither agricultural research nor extension alone will bring about technical change among smallholders. In developing countries two problems arise continuously in technical support systems. First, some service institutions are not present or do not work effectively. If they are present and work, they do not work in a synchronized, coordinated, opportune way. Second, in countries with centralized administration of public services as in Paraguay, institutions are not decentralized but concentrated, having generally no or weak links to local and regional governments, which often results in contradictory actions. Sometimes it happens that local governments buy tractors and ploughs to till the soil for small-scale producers, often even free of costs, while state- or international-sponsored programmes and projects promote CA without soil tillage. Both actors spend a lot of money in these opposed activities. The result is that one service institution invalidates the actions of the other.

4.8. *Lack of continuity of official extension service assistance*

Political changes in Paraguay have brought about massive changes in government extension staff. As a consequence, many well-trained extensionists have lost motivation, left the extension service, and are now working in jobs that have nothing to do with their training. Their knowledge and experience have gone with them. Farmers who had not yet consolidated their CA systems have been left without technical support and assistance, which is crucial especially in the initial phase, which has also contributed to the dis-adoption of CA.

4.9. *Other factors*

4.9.1. *Social changes in rural areas*

Rural areas all over the world have experienced massive changes in recent decades, particularly among small-scale farmers, which is especially true for Paraguay. Electricity, television, cellular phones, and motorcycles have recently conquered almost every household and virtually promoted a social revolution. Young people raised on farms are often not willing to submit themselves to the drudgery and sacrifice of needing to live from what the earth yields with its ups and downs and climatic risks. Instead, massive urbanization has taken place so that often it is the old generation that is left on the farm while the younger people look for better opportunities to make a living in the cities, and often abroad. Fewer and fewer farmers learn and know-how to grow crops and produce food for an ever-growing population.

4.9.2. *Economics of CA/no-till systems on small farms*

While some researchers claim that CA is not profitable on small-scale farms in Sub-Saharan Africa and South Asia (Stevenson, Seraj, & Cassam, 2014), it has been shown that CA/no-till systems are highly profitable in Paraguay (Lange, 2005; Sorrenson, Duarte, & López Portillo, 2001); therefore the economics of the system should be excluded as a cause for dis-adoption here when quality CA is practised.

5. Conclusion

Experience from the tractor-mechanized farmers indicates that CA in Paraguay in general works very well and in terms of continued adoption, or practice, can be a success. However, under the prevailing situation among small-scale farmers, which is far more complex, agricultural sustainability is at risk. Soil fertility deterioration is the fundamental cause of declining crop productivity (World Bank, 2012). Several of the issues described above may lead to failure in the application of CA, resulting in poor yield of crops and economic returns with subsequent loss of motivation and further dis-adoption by small-scale farmers. Poor application of the CA production system by farmers, also resulting from a lack of understanding of many issues (e.g. importance of soil cover and gmcc), will put the sustainability of agricultural production at risk. Soil degradation and loss of fertility of soils will continue to happen. Even a rigid market approach to the diffusion of CA did not prevent the dis-adoption of CA, since other factors appear to be more important in order to achieve a continuous adoption of CA. It is also noteworthy that none of the factors for dis-adoption stands alone, but certainly they have to be seen as 'nets of factors' that interact and are intertwined. Therefore, it seems obvious that efforts need to be made by government bodies and donors to include the experiences described in this paper in order to reverse this situation and make sure that CA projects are supported in a proper way, for a long enough period, and with the right strategy to avoid dis-adoption of implemented sustainable technologies.

We hope that the lessons learned in South America, and especially in Paraguay, in relation to the diffusion of CA among smallholders could help in redirecting strategies in new phases of development projects in this country and, perhaps, elsewhere. Problems in the transition from conventional agriculture to CA mentioned in this paper are not meant to criticize or discourage, they are meant to help avoid repeating the same mistakes again. All problems can be treated as challenges to be overcome! Based on our experiences in Paraguay, we have learned that the properly implemented CA system never fails, and that an underperforming CA system on a farm signals that other factors are the reason for it.

As an example for our hope, in Edelira, Paraguay, there are small-scale farmers at the manual and animal traction level practising CA/no-till continuously since 1992. They had received technical support since the beginning, over a period of more than a decade. The incentives given at the start (inputs and machinery) came together with long-term technical support as a partnership between the farming family and the extension personnel, based on learning the CA system. At least for the last eight years, the farmers have received minimal or no technical assistance from the outside, and yet they successfully continue to practice CA as their production system of choice. This experience shows that when the 'click', the deeper understanding in farmers' minds, has occurred and the farmer decided for himself/herself to change and to continue with the change, seldom will the farmer consider going back to the drudgery of the old system. For this to happen, hard work, time, and patience are needed.

This example underscores our argument that a long-term approach paired with the right strategy is needed for the continuous adoption of CA among smallholders. We cannot expect decades of soil destruction and degradation by tillage to be reversed within only a few years.

As an outlook for further research or accounts of practical examples, based on the experiences presented here, we would encourage seeking more examples of successful long-term CA adoption and adopters, and the reason for it, instead of looking at short-term CA cases that still seem to dominate the ongoing CA development agenda.

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Notes

1. The words development intervention, development aid approaches, project, and programme will be used synonymously.
2. Eastern Paraguay consists of 40% of the country's area, where 98% of the population live. Western Paraguay (Chaco region) is characterized by a different climate and soils, and more importantly agriculture is predominantly livestock. Dixon et al. (2001) classifies it as a different farming system (extensive mixed dry land – Gran Chaco). Furthermore, since only 2% of the population live there, the authors of this paper decided not to include Western Paraguay in this article.

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