



The sustainability of a nutrition-sensitive agriculture intervention: a case study from urban Senegal

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Abstract

The sustainability of nutrition-sensitive agriculture projects has been identified as a research gap, and there is limited research available examining such initiatives in an urban context. We examine the sustainability of a nutrition-sensitive agriculture project implemented in Dakar, Senegal. It included provision of two “microgarden” tables, a henhouse, chickens, inputs, training, and education on nutrition and hygiene. This study was conducted 18 months after the project's end and sought to assess the intervention's sustainability via a survey and in-depth interviews with former project participants. The microgarden tables had poor sustainability: only 5% of respondents continued to use them to grow vegetables. Most of those who continued saw it as a hobby, not a main productive activity. In contrast, 75% continued poultry-rearing activities, and 20% had more chickens than provided by the project. Some former participants had switched to more lucrative models of chicken production, with sales being more common than during the project and considerable revenues earned. This ability to earn income from chicken sales was the dominant motivator of continued production. Nutrition knowledge and practices remained at or near project levels. We discuss lessons for the sustainability of nutrition-sensitive agriculture more generally. These include that in the absence of project-provided incentives, some dis-adoption should be expected; in an urban area, improving incomes may be more relevant than improving production; and behavior change communication likely needs to be re-enforced over time to ensure sustainable changes in nutrition knowledge among parents of young children.

Keywords Nutrition-sensitive agriculture · Sustainability · Urban agriculture · Gardening · Poultry

1 Introduction

Considerable interest in nutrition-sensitive agriculture (NSA) to improve food security is shared by researchers (Turner et al. 2013), funders, and policymakers (e.g., World Bank 2013). There is also general recognition of the need for development projects to aim for sustainability of their interventions and impacts (Scheirer 2005). However, very little is known about the sustainability of NSA approaches and their benefits, which

was identified as a key gap in a recent review of the state of research in this field (Ruel et al. 2018).

Studies of sustainability can help clarify the long-term benefits of interventions (or lack thereof), suggest ways to promote lasting benefits, and improve program effectiveness (Scheirer and Dearing 2011). Indeed, it has been argued that evaluations, especially of innovative programs, are incomplete if not addressing sustainability (Pluye et al. 2005; Scheirer 2005). Despite this, evaluations of sustainability remain rare in comparison to impact evaluations (McNiven et al. 2015). A review by Gruen et al. (2008) found only 24 studies of health program sustainability in low- and middle-income countries, including only one on a nutrition topic (Sebotsa et al. 2007), examining iodized salt in Lesotho). Since then, other nutrition-related rigorous sustainability evaluations have been conducted—McNiven et al. (2015) of vitamin-A-rich orange-fleshed sweet potato (OFSP) cultivation in Uganda, Lorge Rogers et al. (2012) of three Latin American USAID programs, Suchdev et al. (2013) of micronutrient sprinkles use in Kenya, and one of Alive & Thrive in Bangladesh

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(Kim et al. 2018)—but the numbers remain small. It is particularly important to consider sustainability when examining nutrition-sensitive interventions such as NSA, as part of their appeal lies in potentially greater sustainability than typical nutrition-specific interventions due to changing the practices and systems underlying food and nutrition security.

This paper aims to add to this literature through a case study of an NSA program in urban Senegal. The intervention sought to improve food and nutrition security through support for horticulture and poultry production, adapted for an urban context, as well as social behavior change communication (SBCC) on nutrition and hygiene and women's empowerment activities. Eighteen months after the project ended, this study returned to the targeted community to assess the sustainability of the intervention. The results provide useful lessons about the factors facilitating the sustainability of NSA and related initiatives.

2 Background

NSA sits at the junction of health and agriculture and thus should be analyzed in the context of both fields. Across both, sustainability (alternative terms include continuation, maintenance, and durability) refers to the continued use of services, application of practices, or pursuit of activities or to continuation of intended outcomes beyond an initial funding period (Scheirer and Dearing 2011). Sustainability is complex and multifaceted (Savaya et al. 2008), often considered a matter of degree, ranging from full continuation (perhaps even with further diffusion or replication) to full cessation (Chovav and Weinstein 1997).

The literature on health programs suggests a large number of factors that support or detract from program sustainability. Shediak-Rizkallah and Bone (1998) sort these into (a) project design and implementation, (b) host organization, and (c) community. Program-related factors include the existence of program theory, documented effectiveness, flexibility, staff training and skills, financial resources, ongoing evaluation; community factors include community buy-in, political support, and socioeconomic context. In a review of 19 studies, Scheirer (2005) highlights five factors influencing sustainability: (a) ability to modify over time, (b) presence of a “champion”, (c) “fit” with an organization, (d) readily perceived benefits or evidence of effectiveness, and (e) stakeholder support. Scheirer and Dearing (2011) add to this that an intervention is inexpensive or can be delivered by volunteers, existing organizational capacity, and availability of other partners and funding, a point echoed by Savaya and Spiro (2011). This literature, however, is scant when it comes to nutrition or food security programs in low-income countries.

Similarly, little is known about the sustainability of practices and benefits resulting from agricultural projects, particularly whether those adopting agricultural technologies during a project abandon them when it is over, whether they retain knowledge, and whether behaviors continue without support (McNiven et al. 2015). In contrast to health, agricultural research tends to look at the individual (as opposed to project) level, and the issue is often framed as one of dis-adoption of technologies or practices. While studies of *adoption* of agricultural technologies are common (e.g., Feder et al. 1985; Lee 2005; Knowler and Bradshaw 2007), those on dis-adoption are fewer. Most researchers who have examined the phenomenon have found high levels of dis-adoption (e.g., Neill and Lee 2001; Olalekan and Simeon 2015; Grabowski et al. 2016; Srisopaporn et al. 2015; Amsalu and de Graaff 2007; Moser and Barrett 2006; McNiven et al. 2015).

Factors limiting continued use of agricultural technologies (e.g., improved seed) include unprofitability (Duflo et al. 2008), farmers' present-biased preferences (Duflo, Kremer and Robinson, 2008), high labor requirements (Moser and Barrett 2006), risk (Dercon and Christiaensen 2011), and gender issues (Theis et al. 2017). As summarized by McNiven et al. (2015), initial adoption rates are often high, as participants try out a new technology or behavior with support and optimism. Participants experiment with the technology or behavior and learn about its profitability or effectiveness; they may also learn from or imitate one another. These processes may lead to declining adherence over the project lifespan; this trend may accelerate at project end as support is no longer available. Still, if adoption or adherence declines are modest and rates settle at a sufficiently high level, the original project investment may remain cost-effective.

The case study in question focuses on a nutrition-sensitive approach to urban and peri-urban agriculture (UPA). There has been considerable enthusiasm for UPA's potential to improve nutrition and food security (e.g., Egziabher et al. 1994; Lee-Smith 2010; FAO 2007) or empower women (Slater 2001; Hovorka 2006). However, some researchers question how much it can benefit the truly poor (Tevera 1999), whether it can impact nutrition (Webb 2000), and how feasible it is amid numerous constraints, such as limited support services and potential negative environmental impacts (De Bon et al. 2010). Using national survey data for 15 developing/transition countries, Zezza and Tasciotti (2010) find that UPA's share in income and agricultural production is very limited but can be an important source of livelihoods, with a positive statistical association with dietary adequacy indicators. In a systematic review, however, Korth et al. (2014) concluded that rigorous evidence of impact of UPA on food security or nutrition was effectively nonexistent. Impact evaluations of projects promoting UPA have been few (e.g., Gallaher et al. 2013), and no researchers to date have examined the sustainability of any such projects.

3 Case study overview

The CHANGE project, funded by Global Affairs Canada and implemented by Helen Keller International (HKI), aimed to improve the nutritional status of women and children under 5 years of age by encouraging women to produce vegetables and eggs, improving nutrition and hygiene practices, and supporting women's empowerment. The intervention consisted of three main components: horticulture, aviculture, and SBCC on nutrition and hygiene. Some areas also participated in a women's empowerment curriculum. The horticulture support included providing each participating woman with two locally produced micro-garden tables (each 1.2m² in area), designed based on an FAO model (FAO 2010). In place of soil, the microgardens used a substrate; a liquid mineral fertilizer was added to this to support plant growth.¹ At the time of table installation, each woman also received an introductory training on gardening and an annual supply of seeds and the liquid mineral fertilizer.

For the aviculture component, one movable locally produced chicken coop was delivered to each participant's home, at which point they she was trained on best practices for rearing chickens. Each participant received three improved-breed laying hens and one improved-breed rooster and was expected to contribute a local-breed hen to the flock to incubate eggs. Given the nutritional advantages of eggs (Iannotti et al. 2014), the goal of the poultry component was egg production, and a laying breed was chosen accordingly. The project encouraged consumption of eggs and vegetables by the households, though surplus could be sold for revenue. The design was guided by program theory (Herforth and Harris 2014), and impacts on nutrition were expected to be achieved through consumption of production, not income, given the small scale of the intervention. SBCC was conducted by a local NGO partner through monthly group sessions and home visits led by community-development agents (CDAs) who received a monthly stipend plus three micro-garden tables and a henhouse, to incentivize them to support others in their community as 'model farmers.' During the SBCC visits, the CDAs were also meant to inquire about the microgardens and henhouses and provide participants with technical support for them as needed. Project sustainability was expected to be achieved through three channels: (1) imparting sufficient knowledge that participants could continue activities independently; (2) training CDAs who would continue to live in the area after the project ended; and (3) ensuring ongoing access to inputs by training participants on how to make them and where to buy them. However, no ongoing financial support (such as CDA stipends or input subsidies) was provided after the end of the project.

¹ The micro-gardens could also be cultivated if filled with fertile soil, but this was not the recommended practice.

The project was implemented in a densely populated neighborhood of Dakar, Senegal in 2013–2016. Inclusion criteria for the project included living in the project zone and being a mother or female guardian of a child under 5. There were 1,305 participants. Project coverage was high due to the in-home delivery approach. Mid-project monitoring surveys revealed table use to be around 97%, chickens to be kept by 100% of participants, and 84% to have attended a group SBCC session in the prior month. In line with McNiven et al. (2015), these levels had all fallen somewhat by the project's endline survey (Jan. 2016), which revealed that 73% of participants had attended a group SBCC session in the prior month, 51% had a microgarden table in use, and 96% had a functioning henhouse. Almost no surveyed participants had sold production from either tables or henhouses. Knowing whether dis-adoption continued after the end of the project is thus critical for evaluating its success.

4 Methodology

Definitions and indicators of sustainability vary widely. Some focus on sustaining program benefits (e.g., Rosenberg et al. 2008), others on staff/volunteer retention (e.g., Abbey et al. 2014; Ahluwalia et al. 2010; Vamos et al. 2014), activities by former trainees, staff, or volunteers (Bossert 1990; Blanchet et al. 2014; Mbanefo et al. 2010), knowledge or skills (Wilson et al. 2014), participants' practices (Kachur et al. 1999), or resources (e.g., Le Gargasson et al. 2013). Scheirer and Dearing (2011) suggest using one or more of six clearly defined outcomes: (1) maintaining benefits for participants; (2) continuing activities; (3) maintaining partnerships; (4) maintaining new organizational practices; (5) sustaining attention to an issue; and (6) diffusion or replication. They also recommend assessing sustainability no sooner than one year after funding ends and note that a nonexperimental approach will usually be necessary and may be preferable, given time lags and the importance of contextual factors. Wiltsey Stirman et al. (2012) highlight the need for reliance on observations, in addition to self-reports, and for qualitative methods (echoed in the agricultural literature by Grabowski et al. 2016).

This case study followed these recommendations. We focus on participants' *practices* and define our main metric of sustainability as: continued use of the project-provided infrastructure to grow vegetables and/or raise poultry. We are also interested in the extent to which this is done with high quality (i.e., using the improved practices promoted by the project) and potential impacts on diets. Secondly, we consider nutrition and hygiene knowledge. We also examine participants' motivations for continuing to garden or raise poultry after the project.

Two main data collection methods were used. First, a cross-sectional survey was administered to a sample of

247 former project participants (approximately 20% of the total) and 15 CDAs in August 2017, 18 months after project end. Respondents were chosen randomly from lists of participants maintained by HKI during the project. The questionnaire covered participation in project activities, nutrition knowledge and practices, microgarden table and henhouse use, and basic sociodemographic information. To minimize acceptability bias (i.e., falsely reporting continued use of project-provided items), the survey included observations to assess the current existence and functionality of the tables and henhouses as well as recent production. A simple set of observation-based criteria were used to assess functionality. To verify results, the questionnaire required that geo-coded photos be taken of each henhouse or table, which could later be cross-checked against the data entered. Survey questions related to the main outcomes were asked openly, without providing answer options, and a handful of open-ended short answer questions about reasons for continuation/disadoption were included; responses were later categorized for analysis.

Second, semi-structured interviews were conducted with 20 women who were particularly successful at continuing to apply the promoted practices. The sample size was considered sufficient to cover the diversity of viewpoints on barriers/facilitators to gardening/chicken-raising (Guest et al. 2006). Sampling was purposive: based on the survey results, we identified women who continued to produce chickens/vegetables in significant quantities and particularly those who had expanded production. Interviews were semi-structured using open-ended questions and covered motivations to continue, challenges and rewards, production, and sales. Interviews were conducted in Wolof by a native speaker, audio recorded, transcribed, and translated into French for analysis.

Qualitative data was transcribed and analyzed for key themes, focusing on facilitating factors and barriers, using nVivo software. A list of starting themes was identified a priori but many were added during the analysis phase, which was iterative (Guest et al. 2011). Quantitative data was collected via tablets, uploaded to a Cloud-based server, checked for aberrant values, labelled, and coded as necessary. Analysis was performed using Stata SE15 (StataCorp). In Section 5, quantitative data is compared to data from three project monitoring surveys, which took place during the project's second and third years. These covered an average of 140 project participants each, selected randomly from participant lists. Content included coverage of project activities, nutrition practices, and garden and henhouse production.

Approval for the study was granted by the national ethics review board, *Comité National d'Ethique pour la Recherche en Sante*, dossier number SEN17/34. Informed consent was obtained before all individuals were interviewed; there was no compensation for participation.

5 Results

5.1 Sample overview

Summary socio-demographic statistics for the survey respondents are given in Table 1. All respondents were women. The right-hand columns of Table 1 show asset ownership, used as a proxy for wealth. Comparison to data from the 2017 Senegal Demographic and Health Survey (last column; ANSD and ICF 2018) shows that households are of about average wealth by urban standards—though this is well above standards in rural areas, where only 35%, 29%, and 5% of households have electricity, televisions, and computers, respectively (ANSD and ICF 2018).

No participants had microgardens prior to the project, but 31% had some prior experience with raising chickens. Nearly all respondents remembered participating in CHANGE activities, particularly group discussions on nutrition topics. Home visits on nutrition and agriculture topics were cited by about two-thirds of participants.

5.2 Horticulture

Considering the continuation of project-promoted gardening, the most basic indicators assessed were whether the respondent had kept the microgarden tables provided during the project, whether they remained in a usable state, and whether they were being actively used to grow vegetables. As noted above, this was verified by observations, with pictures taken. The vast majority of respondents (73%) had no tables present, while 2% had only one table, and 23.7% had both tables. Among those who still had at least one table, most (63%) had no tables in usable shape. The vast majority of those with tables (81%) were not using them currently. Only 14 respondents (5% of the sample) continued to use the micro-garden tables to grow vegetables at the time of the survey. As the survey was fielded during the rainy season, the most difficult time of year for growing vegetables in Dakar, it is likely that there was some seasonal stoppage: indeed, 22% of respondents claimed to have used it in the past six months.

During the project, however, monitoring data showed use rates to be as high as 97%, though this had declined to 51% at project end. There was thus considerable dis-adoption of microgardening after the project: the majority of project participants not only were not actively gardening, they had not even retained the tables to have the option to re-start.

Participants' main reasons for disposing of the table were it breaking (38.6%), lack of space (32.5%), difficulties with the table during rain (12.9%), home construction or moving (7.2%), or a lack of inputs (4.1%). Considering reasons why a table was not used (among those who had at least one table), 54.8% cited it damage and 23.3% cited a lack of space. In households where the table was used, the

Table 1 Summary statistics

Summary Statistics				
Sample Size	262	Percent of households owning		
Average Age (yr.; mean, SD)	42.4 (11.2)	Sample	Urban DHS	
Percent married	83%	TV	96.2%	82.7%
Of those, pct. in polygamous marriages	30.5%	Fridge	47.7%	46.1%
Percent completing primary education	37.8%	Antenna	21.7%	10.1%
Percent completing secondary education	13.4%	Fixed-line phone	4.6%	5.5%
Literacy rate	42.4%	Electricity	97.7%	90.1%
Avg. number of children	4.9 (2.5)	DVD/CD player	5.7%	14.8%
Avg. age of youngest child (yr.)	3.6 (3.5)	Internet	3.4%	10.6%
Percent with children under 2	36.3%	Satellite TV	19.4%	22.3%
Percent with children under 5	76.0%	Computer	8.4%	25.1%
CDA	5.7%	Personal Car	1.5%	10.6%

(female) project participant was overwhelmingly the main user (92%); only one husband was reported to use the table. Most former project participants (51%) cited having sources of advice on micro-gardening available to them nearby (generally the CDA).

The vast majority of table users described the table as a moderately important or important source of food, with two citing it as the main source. Among the 14 respondents who were actively growing vegetables at the time of the survey, main crops grown were dark leafy greens, okra, and tomatoes. 58 respondents (22%) reported harvesting vegetables from their tables in the prior 6 months. These crop choices show considerable overlap with those promoted by the project (okra and hibiscus leaves) and could contribute to gaps in the diet (e.g., vitamin A, fiber, small amounts of iron). Among those harvesting vegetables, however, average harvest sizes in the prior six-month period were small—e.g., 2.6 kg of okra and 3.3 kg of hibiscus leaves. The food security and nutrition contribution was thus fairly minor.²

Only nine respondents reported selling vegetables from the table in the past 6 months, with median earnings of 5,000 FCFA (about 8–9 USD).³ While not a large amount, few women in this community have formal employment, thus even a small amount of income, when personally owned, could be influential.⁴ However, no respondents considered the table to be a main source of revenue.

² Production data is based on recall; most harvests would have occurred gradually over time and would not have been weighed or recorded, so recall and estimation issues likely make data noisy.

³ This compares well to estimated average *annual* theoretical revenues, 7,000 CFA per table (Sposito 2010).

⁴ For comparison, prices of relevant food products in Dakar: kilogram of onions: 300–400 FCFA, kilogram of rice: 300–500 FCFA, 1 dozen eggs: 1100 FCFA, a chicken: 2500–3000 FCFA; a monthly salary for a maid could be as low as 20,000 FCFA.

5.3 Aviculture

Turning to the aviculture portion of the project, 49.4% of respondents kept chickens at the time of the survey, and an additional 25% reported doing so in the prior 6 months. Thus about 75% of the sample was considered to be continuing poultry-rearing activities. The henhouse was present in 78% of households. In terms of quality, 82% of inspected henhouses were found to be in useable shape. Adherence to project-promoted practices was fairly high: 73% of chickens were fed supplementary feed, 68% of henhouses had feeding trays in them, and 82.5% were clean. These levels are all slightly below those seen at the end of the project, which were very high (93–98%) amid close support and supervision.

For those ($n = 57$) who had not kept the henhouse, the main reason cited was a lack of space (37% of respondents), while 19% cited it being degraded, 17% claimed it was being kept elsewhere but still used, and 11% cited wanting to avoid rainy season damage.

Among those actively raising chickens, some had diversified into other breeds: whereas the project provided laying hens, the majority (69%) of those raising chickens 18 months later were raising broilers (alone or in combination with other birds), generally due to greater marketability. Flock size was generally larger than at the end of the project, as was the average number owned by the participant herself (as opposed to another person in the household) (Table 2). On average, 90% of household chickens belonged to the respondent herself. The original (female) project participant was generally the main henhouse user (80%); 13% of henhouses were being used by the husband or another male household member.

As shown in Table 2, egg production fell when compared to the end of the project, likely because of aging hens and the shift to raising broilers. Fewer households with chickens had produced eggs in the prior 2 weeks. Among those that did, the

Table 2 Chicken ownership and production, as compared to project end

	End of Project (Jan/Feb. 2016)	Follow-up Aug. 2017
Among those with chickens:		
Mean (SD) number of adult chickens (household)	4.4 (2.6)	6.0 (13.8)
Mean (SD) number of chickens, including chicks (household)	6.1 (4.5)	7.1 (13.9)
Mean (SD) number of adult chickens (respondent)	2.1 (2.3)	5.6 (13.1)
Mean (SD) number of chickens, including chicks (respondent)	3.3 (3.7)	6.5 (14.2)
Pct. producing at least one egg in past 2 weeks	83%	52%
Mean (SD) number of eggs (among producers)	25.5 (14.8)	17.3 (18.7)
Mean (SD) number reported consumed by household	14.6 (10.6)	7.6 (6.6)
Mean (SD) number reported consumed by youngest child	6.3 (4.6)	2.6 (2.5)
Pct. eating a chicken in last month	31%	n/a
Pct. eating a chicken in last 2 weeks	n/a	27%
Pct. eating a chicken in last 4 months	n/a	78%
Pct. selling a chicken in the last 4 months	7%	29%
Mean (SD) number sold	n/a	13.3 (16.9)
Median revenue (past 4 months), FCFA	5,000	22,000

'n/a' indicates data unavailable due to changes in survey questions

numbers produced and consumed were smaller: on average, an egg-producing household had collected 17 eggs in the past 2 weeks, of which slightly more than half (9) were consumed by the family. Egg sales remained rare, but chicken consumption and sales increased compared to project end, and median revenue was considerably higher.⁵ Eight respondents had earned over \$100 in the past four months, up to a maximum of \$425. Of note, the distributions of chicken owned and eggs produced were highly skewed, indicating that a handful of former participants were doing particularly well.

5.4 Differing profiles of continuers and disadopters

Table 3, below, compares continuation rates for table gardening or chicken rearing across different demographic groups: wealth, age, marital status, literacy, and whether the respondent was a CDA. Those with lower wealth were more likely to continue gardening, though this made no difference for chicken rearing. In addition, those who were older were more likely to continue either activity (though the difference is only marginally significant for chickens), as were CDAs (only significant for chickens). There were no significant differences based on literacy or marital status.

5.5 Use of revenues

Among those women ($n = 75$) earning revenues from a hen-house or microgarden, nearly all reported making the decision of how to use those revenues themselves (87–95%) or

in agreement with another person (8%). Only two women reported that their husband made these decisions. Main reported uses of these revenues were buying food (79% of respondents, 41% as the main use), production inputs (namely chicks and chicken feed, 45%, with 33% as the main use), clothing (29%, with 13% as the main use), healthcare (27%, none as the main use), and savings (9%, 3% as the main use). Considering the food items purchased with this money, the most cited were oil (46% of food purchasers), rice and other grains (41%), vegetables (36%), fish (34%), sugar (25%), meat (14%), salt (14%), and poultry (10%). Thus, although revenues were earned by only about 28% of respondents and were modest, they were largely used to enhance household food security. While the two main items purchased, oil and grains, may not have had a positive nutritional impact in this population (where obesity is a concern, particularly among women⁶), vegetables, fish, meat, and poultry may. There thus appears to be a slight but meaningful sustained contribution to household nutrition through the income-generation pathway of the intervention, due to the poultry-rearing component.

5.6 Nutrition and hygiene knowledge and practices

Respondents were asked a set of questions on their knowledge of key young child nutrition and hygiene practices, as shown in the top rows of Table 4. Levels generally compared favorably to those found during the project, being at or near the maximum levels, with one exception: only 31% were able to

⁵ This four-month period included Korité, a key holiday for chicken sales, whereas it did not in the final project survey.

⁶ Overweight prevalence in Dakar is 19%, with central obesity at 26–40% (Macia et al. 2016).

Table 3 Differences in continuation

	Continued gardening	Continued chicken rearing
Bottom third of wealth	9.0%	70.0%
Top third of wealth	1.3%	75.0%
p.	0.024	0.457
Older than 50	9.1%	79.2%
Younger than 30	1.2%	65.8%
p.	0.023	0.060
Married	5.5%	73.9%
Unmarried	4.6%	77.3%
p.	0.796	0.635
Literate	5.4%	78.4%
Illiterate	5.3%	71.5%
p.	0.970	0.209
CDA	13.3%	100.0%
Not CDA	4.9%	72.9%
p.	0.156	0.019

p values are for a Pearson Chi-squared test of significant difference in continuation rates between the two demographic categories in question. *P* values are in bold for $p < 0.05$

name all five ‘critical moments’ for handwashing with soap, down from 76% at the highest level.

To understand the extent to which nutrition practices were maintained after the project, a series of questions was asked about women’s and children’s consumption in the past 24 h. These were used to calculate standard nutrition indicators (WHO 2010; FAO and FHI360 2016), which were compared to the levels found by monitoring surveys during the project.⁷ As there is no control group or baseline data, we cannot identify impacts of the project, just note trends among participants during and after project end. Overall, values for all indicators were within the range seen during the project, though slightly lower than their maximum levels. The main exception to this was exclusive breastfeeding in past 24 h for children under 6 months, which was notably lower than during the project; however, the sample size for this indicator in the follow-up survey was small ($n = 22$). For hygiene practices, the main focus was placed on the existence of a handwashing station, as promoted by the project. There was a large decrease in prevalence of home handwashing stations between the end of the project and the follow-up survey.

5.7 Drivers of continuation

The survey included open-ended questions on reasons for not continuing to use the table or henhouse. These responses yielded a clear set of barriers for those who did not continue: tables or henhouses had degraded or broken (52% of disadopters for

⁷ The July 2015 survey was fielded during Ramadan, which may have impacted nutrition practices.

tables; 37% for henhouses) and there was limited space (32% of respondents; 45% for henhouses). Given the strong level of convergence around these barriers but little insight into facilitating factors, in-depth interviews were used to focus on motivation to continue the project-promoted agricultural practices. These are presented using illustrative quotes where useful; coding in parentheses after each quote indicates the respondent number and whether she was a CDA (“C”) or a normal participant.

5.7.1 Consumption as the main use

Household consumption was the main use of production; all interviewees mentioned its importance, often for large portions of the interview. Plants grown were those consumed regularly and figuring strongly within Senegalese cuisine. Gardeners appreciated having a steady, nearby supply of items used regularly. Similarly, all respondents in the poultry-focused interviews reported consuming both chickens and eggs. For some, this was a substitute for buying; for others, it was a new addition (or more frequent one) to the diet. This was particularly true of eggs, and respondents routinely cited children as the main recipients of the eggs—in line with project messaging, which emphasized the importance of eggs in young children’s diet. One participant even cited selling eggs as being an option only available to those without children—the assumption being that anyone with children should be giving the eggs to them. Respondents also reported consuming chickens at home; for some this was regular, a few times a month, while for others it was tied to special events, whereas egg consumption was nearly daily. About half appreciated home-produced plants as being cleaner or organic, however, this did not emerge as a priority motivating factor—it was usually mentioned in passing and briefly.

5.7.2 Sales central to poultry production but not gardening

Sale was a central motivator for continued poultry production, with most women citing money as their main motivation. While sales were fairly rare during the project, all but one of the top producers interviewed had begun to sell chickens since it ended. Nearly all of these sales were the result of raising short-cycle broilers, often at fairly large scales (20–150 chicks). To facilitate this, women either expanded the henhouse, bought other henhouses, or found space in others’ houses.

For example, one woman (a 39-year-old mother of nine) obtained her father’s permission to raise 150 chicks in his courtyard to sell for *korité*. She suffered some losses to mortality but, with the help of her son, was able to enter into a contract with a restaurant to sell the remaining broilers for a total of 250,000 FCFA (USD 450). This money was then reinvested in another production cycle and used to cover household expenses. In the future, she hoped to enlarge her

Table 4 Time trends in nutrition and hygiene knowledge and practices

Dates of Survey	Feb. 2015	July 2015	Feb. 2016	Aug. 2017
Caregiver's Nutrition and Hygiene Knowledge				
Exclusive breastfeeding of children <6 mo.	68%	76%	76%	78%
How to manage low breastmilk volume	19%	53%		44%
How to enrich porridge (at least one ingredient)	95%	98%	98%	96%
Feeding a child more when sick	36%	59%	37%	57%
Pct. able to name all 5 critical moments for handwashing with soap		27%	76%	31%
Nutrition practices				
Average women's dietary diversity (MDD-W)	5.52	6.73	7.49	5.66
Pct. of women meeting MDD-W (5+ of 10 groups)	83%	90%		73%
Pct. Of Children 6 mo. - 5 yrs. consuming ___ in past 7 days...				
Eggs	65%	87%	73%	60%
Meat and poultry products	90%	90%	74%	78%
Milk products	90%	93%	82%	81%
Dark leafy greens		54%	39%	49%
Other vitamin-A rich fruit and vegetables	86%	87%	81%	79%
Orange-fleshed sweet potato		49%	60%	48%
Pct. of children 6 mo.-5 y. eating at least 3 times in past 24 h.	67%	81%	65%	72%
Pct. of children 0–2 y. breastfed in past 24 h.		72%	74%	75%
Pct. of children 0–2 y. no longer breastfeeding		26%	21%	20%
Pct. of children 0–6 mo. breastfed in past 24 h.	94%	100%	92%	86%
Pct. of children 0–6 mo. exclusively breastfed in last 24 h.	69%	50%	68%	35%
Hygiene practices				
Pct. With a handwashing station within the household	56%	85%	99%	65%
Of those, pct. With soap	76%	84%	91%	70%
Of handwashing stations, those within 10 steps of kitchen	55%	19%	26%	21%
Of handwashing stations, those within 10 steps of latrine	52%	16%	3%	21%

production, as she saw opportunities to sell more to her existing buyers.

In contrast, sale of vegetables was a far secondary motivator when compared to household consumption. Only three interviewees mentioned selling their products, and all of them cited consumption as also being an important use. Even among those who did sell, it would never be a true 'livelihood'.

Microgardening... cannot be compared to a salaried activity. [But]... while there certainly isn't much money one can earn from selling cultivated produce, one can still take care of many things with this money. 1C

Economic benefits from the tables were mainly perceived through substitution for purchases, as opposed to income. Getting even small amounts of cooking ingredients from the tables allowed women to avoid depending on others for money or having to dip into their small savings:

What motivates me to garden is reducing my family's daily expenses. These expenses can be lightened if one produces certain foods, like lettuce, hibiscus leaves, okra... Having the products at one's one home means one no longer has to buy them to cook. 1C

The income from chicken sales was highly appreciated and used to meet regular expenses, particularly for schooling and

healthcare. A stock of chickens that could be sold at any moment also buffered households from larger shocks, increasing resilience:

One can manage many needs with the henhouse. For example, one day I was prescribed a 3.000 FCFA prescription for my child. So, I sold a chicken to pay for it. The feeling of being able to manage my problem through my own chicken-rearing really encouraged me to continue. 4B

The income proved empowering, allowing women to play a larger role in managing household economics. While none of the women interviewed had a formal job, some had other small commerce operations, such as facilitating money transfers for neighbors. Poultry-rearing was used to complement and add to these operations, which were both a source of money to buy poultry inputs and a destination for poultry revenues.

5.7.3 Gifting one's products played a social role

Another important value of the produce was gifting (important in Senegalese culture). All interviewees mentioned providing table-grown products to neighbors or relatives. Crop choice reflected this: mint was not promoted by the project but was widely grown among those who still used the tables 18 months afterwards.

Mint has a cultural role in Senegal: it is used to flavor tea that is regularly drunk as a social activity. The ability to grow and gift this, though small, appeared to be valued by the gardeners, as it played a key role in cementing their social place in the neighborhood. Eggs were also commonly used as gifts.

5.7.4 Nutrition was a minor motivating factor

Six of nine respondents in garden-focused interviews, including all four CDAs, mentioned some aspect of nutrition as being important in their continuation of micro-gardening. Two named specifically vitamin-rich plants; others spoke more generally about fighting against hunger or malnutrition. Very few named nutrition explicitly as a motivator for continuing the poultry-rearing activities. CDAs tended to speak in much more detail and at much more length about the importance of nutrition (84% of interview material related to nutrition came from CDA interviews), which is unsurprising, as they were trained in nutrition education by the project. However, nutrition did not appear to be an important motivator for most interviewees. This was also reflected in changing crops to things like cucumber and lettuce (not rich in key micronutrients) and mint (not eaten in significant quantities).

5.7.5 The husband's approval was necessary, but it remained the woman's activity

All married respondents cited that they had gained their husband's support for keeping the microgarden tables and/or hen-houses in the household; most underlined the importance of this for their continued gardening and/or poultry-rearing. This is unsurprising, as women tend to have a limited decision-making role in Senegalese society and a table or henhouse would occupy prized limited space within a household. Husbands also provided concrete support for chicken-rearing for about half of respondents, particularly for repairs or purchasing more expensive inputs. For two of the top chicken-raisers and three of the top gardeners, the husband had become an active partner in production, but these women still felt that it was generally 'their' enterprise.

5.7.6 Those who continued adapted the approach

The project promoted a very specific use of the microgarden tables: substrate and a nutrient solution in place of soil, with hibiscus leaves and okra as the main promoted crops. During the project, these inputs were provided for free. This proved a critical gap for many participants; lack of inputs was commonly reported as a reason to cease production. Among those continuing to use the tables, however, most found alternative solutions, including experimenting with other crops. The ability to experiment and *not* follow the project's advice thus allowed them to continue cultivating.

Similarly for poultry inputs, most successful women had found ways to make their production self-sustaining, adding to their flock and using profits from chicken sales to restart production or cover feed and vaccination costs. While some continued to apply the practices as taught by the projects, others adapted them, such as changing to partial scavenging or augmenting chicken feed with left-over food. Most of the most successful poultry-keepers had added new chicken breeds to their flocks. In addition to broilers, a few respondents had experimented with ducks, quails, or other improved-breed chickens, citing higher prices or productivity. Overall, however, the project-provided chickens were appreciated as good layers, and most respondents had kept these on hand.

5.7.7 Passion, interest, and pride were key motivators

A surprising emergent theme from the gardening interviews (but not those on poultry) was passion. Several of the continuing gardeners cited having found a true personal interest in their microgardens:

The work I put into microgardening was a passion for me. And that's how it works: one must put love into this work to succeed I managed to continue where others gave up because micro-gardening is an integral part of me now. It's like a medicine that I cannot do without. Just contemplating the greenery, after the sprouts grow and reach a certain height, gives you satisfaction and motivates you more. 1C

Micro-gardening is an activity that I really like. I had never experienced anything like it before. But I was astonished the day that I saw the first plants I had sowed coming out of the earth. It was as if I had been transported to another continent, it was so beautiful to see! ... An activity into which one puts one's heart can't be compared to one that is imposed from the outside. There must always be a passion to succeed in microgardening, and it is this passion that animates me and has kept me gardening until now. 19R

For CDAs, another motivator was pride in their role as experts and resource people, particularly when there was outside recognition of it. The project augmented their sense of identity, which may have encouraged them to continue their activities. This created a beneficial cycle, whereby pride encouraged CDAs to continue gardening, become better at it, and continue promoting it; this, in turn, increased their knowledge and made them more known as local resource people, feeding their pride in this identity. While CDAs were not identified due to an interest in gardening or access to resources, they did receive more in-depth training and inputs. This additional training

proved particularly useful when it came to needing to repair and maintain the tables after the end of the project, helping support sustainability. Moreover, their role as promoters both increased their belief in the usefulness of the activity and made them feel a need to set an example.

5.7.8 Some 'barriers' were easily overcome by motivation

Maintenance of tables, a major reason for dis-adoption, posed problems for even the top growers. For henhouses, however, owners were generally able to repair any damage. The main factor behind this difference appeared to be more motivation to maintain the henhouse as needed; this was weaker for the tables, likely due to less evident benefits. Additionally, it appeared that husbands were more readily providing help (financial or labor) with repairs for the henhouses, perhaps due to a greater value of the production in their eyes. A similar dynamic occurred with space (in this crowded urban setting). Insufficient space was the overwhelming barrier to continued use of the tables, and it emerged occasionally as a constraint even for the most successful producers, who cited challenges with expanding production due to small houses. However, those who were truly motivated found ways to circumvent this problem, finding or prioritizing space. For the henhouses, space constraints were surmounted, including by negotiating with family or other tenants. These thus proved to be 'soft' constraints, which could be overcome by prioritization.

5.7.9 Unimportant factors

Some factors identified *a priori* proved to be unimportant in facilitating continuation. First, the scale of production was not important: some of those who continued did increase production, but the majority did not. Similarly, prior experience with gardening or chicken-rearing was not clearly a facilitating factor for continuing: some of the most successful gardeners / chicken keepers did have prior experience, but most did not. Finally, time was not a major barrier to continuing: all interviewees considered the time spent on gardening and chicken-rearing to be minor and to fit well with their domestic activities. This is in contrast to other studies of NSA projects, where women's limited time has constrained adoption (e.g., Muehlhoff et al. 2017).

6 Discussion

Before discussing the results, we must note several limitations to this study. First, this is only one case study, using one particular approach to urban NSA, and the results should be extrapolated with caution. Second, this

study was undertaken 18 months after project end; it is unclear whether such trends would persist longer term. There are also seasonal variations that may have impacted outcomes. No data was collected on nutritional status, so no conclusions can be drawn about such impacts. Finally, while some information on motivations among less-successful participants was collected, in-depth interviews focused on the most successful, limiting the conclusions that can be drawn about how their motivations compare to others'.

However, some insights can be gleaned from these results to add to the literature on adoption and sustainability. First, this study confirms the pattern of widespread disadoption of agricultural technologies (e.g., Neill and Lee 2001) to apply also to NSA technologies; indeed, the profile of rapid adoption followed by more gradually declining use noted by McNiven et al. (2015) was generally seen here, with a rapidly accelerated decline in microgarden table use after project end. We also find resonance with a factor identified commonly in past literature as motivating disadoption: unprofitability of the technology at hand. In contrast to some of the literature, however, we find disadoption rates to be significantly lower among poorer women (in terms of assets). We generally did not find that gender issues played a key role in disadoption – e.g., men capturing the benefits of the activity at the expense of their wives (e.g., Theis et al. 2017; Dumas et al. 2017). Women generally reported being the primary one responsible for the table or henhouse and almost universally responsible for determining the use of the resulting revenue.

Methodologically, our results underline that disadoption is not binary; the researcher must be clear on the *goal* of adoption to determine whether a change in the application of the given technology should be considered disadoption. In this case, chickens were still being raised but often not for home egg production and consumption, as had been envisioned by the project. Instead, the most successful former project participants had experimented with different poultry types, expanded henhouses, and/or forged partnerships with larger buyers to transform a small-scale activity into a livelihood. This echoes a finding noted by others (e.g., Chambers et al. 2013; Wakerman et al. 2005) examining health projects: flexibility helps support sustainability.

The project exhibited several of the program design factors noted to be relevant for sustainability: flexibility, grounding in program theory, training, and regular evaluation through monitoring. However, no financial resources were provided to support activities or ongoing evaluation after project end. The lack of financial resources had a clear connection to disadoption: a main motivation for continuing poultry production instead of gardening was that it proved lucrative and thus was financially self-sustaining.

The project's program theory had assumed that improving income was not a relevant pathway to improved

nutrition in an urban context, instead prioritizing own consumption. In contrast, this study found only a low level of reported home consumption, in line with prior research on the contribution of UPA (Korth et al. 2014). Over time, most participants dis-adopted the low-value gardening, which became largely a passion project for the handful of women who were interested in it. However, most continued poultry rearing, and the ability to earn income was the main reason cited for this by the most successful producers, highly valued by women who had little access to formal jobs. Moreover, respondents cited that it was used for purchasing food, potentially benefiting household nutrition and food security. This suggests that the ‘income’ pathway to improved nutrition may likely be more relevant to target than the consumption pathway in an urban NSA approach, where participants have good access to markets; this aligns to findings that the link between agricultural production and diets is weaker in areas with good market access (Ruel et al. 2018). However, the empirical data collected on income use was limited: it did not consider income substitution, amounts of foods purchased, or how these were allocated within the household. Thus we can make no definitive conclusions about the viability of this pathway. Indeed, while some past studies have shown increased income through NSA projects (e.g., Alaofè et al. 2016; Kidoido and Korir 2015), only one (Passarelli et al. 2018, examining an irrigation project in Ethiopia) have clearly demonstrated causal links between this income increase and impacts on nutrition. Gillespie et al. (2012) notes that while greater agricultural productivity typically increases production, income, and consumption, none of these automatically translates into better nutrition; others have cited income effects as an important gap in NSA research (Webb 2013).

Moreover, former participants tended to shift to broilers, whereas the project had promoted laying hens for egg production and emphasized the importance of eggs for young children. Average egg consumption thus declined significantly after project end. Chickens were eaten more rarely than eggs, so this shift thus likely decreased the direct effect of the project-promoted activities on food and nutrition security. Whether an indirect effect, through income, offsets this depends considerably on the use of that income—in this case, oil was the main food item cited as purchased, implying that nutrition impacts could have been negative as well as positive. Future NSA projects that seek to use income to improve nutrition will thus need to pay greater attention to messaging focused on the use of income to improve nutrition.

Indeed, despite a strong nutrition-focused SBCC strategy, nutrition and health were rarely cited by former participants as important reasons for continuing to use the henhouses or tables. Even though nutrition knowledge levels remained high

after the end of the project, this did not prevent dis-adoption. Taken together with the shift seen in chicken production, this suggests that NSA projects might do better to align themselves with more enduring motivators, such as increased income and empowerment, than with nutrition and health benefits alone. This requires identifying win-win interventions that will boost income or create new livelihood opportunities while also improving nutrition and food security.

Levels of knowledge of key young child nutrition and hygiene practices were typically at or near the maxima seen during the project, while indicators for nutrition practices were mostly within the range seen during the project, slightly lower than maximum levels. These profiles are similar to those found by Kim et al. (2018) in Bangladesh: nutrition knowledge and best-practice indicator levels falling after the end of the project but remaining above their minimum levels. Amid no ongoing exposure to project BCC, natural forgetting over time, and a lack of regular reminders, some fall-off in such outcomes is expected; that they remained comparatively high should be taken as an encouraging (though suggestive) sign of the value of nutrition BCC. However, it should be noted that few respondents were still caring for a child in the 1000-days window at the time of the follow-up, due to children’s aging: to ensure best practices reach new cohorts of young children, BCC would need to be reinforced over time until a critical mass of adoption was achieved and the practices became local norms (Kim et al. 2018).

7 Conclusion

This study examined the sustainability of an urban nutrition-sensitive agriculture project 18 months after it ended. The gardening component of the project experienced considerable dis-adoption after project end; for those who continued, table gardens generally made only minor contributions to household food security and nutrition. In contrast, the poultry-rearing component experienced fairly low levels of dis-adoption. Those who continued tended to be successful at increasing flock size, with changes in breed leading to increased sales and revenues but fewer eggs produced. Any meaningful sustained contribution to household nutrition would thus have to come through income generation from poultry. Nutrition knowledge and practices remained at or near the levels seen during the project. Overall, conducting the post-project evaluation offered useful insights on participants’ priorities and preferences, as revealed through the activities they chose to pursue in the absence of project incentives; most evident among these was the paramount importance of income-generation in driving choice. The study also confirmed that dis-adoption or adaptation of project-promoted technologies/practices should be expected; within nutrition-sensitive

programs, this may include shifts to adjacent technologies or practices that are less nutrition-sensitive. Initial impact evaluations should take this into account when interpreting their results.

The results shed light on components influencing the sustainability of NSA and urban agriculture for food security initiatives. In particular, given the strong pull of income generation, found to be a greater motivator than nutrition per se, NSA and food security initiatives should seek activities that can bolster both income and nutrition or refocus communication efforts on how newfound income can be used to improve nutrition and health. Other actions to support sustainability or institutionalization of urban NSA in the future could include integrating community volunteers into existing government volunteer cadres, providing them with non-financial incentives (such as recognition ceremonies and trainings), developing systems to enroll new parent-child pairs on an ongoing basis as children are born, and ensuring that infrastructure designs are well-adapted to the local environment. Future research efforts could focus on testing alternative models for urban NSA, better capturing the production-to-income pathway within market-embedded urban settings (including substitution effects and purchase of unhealthy foods), and examining potential environmental health impacts of poultry production in home-based urban settings.

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Compliance with ethical standards

Ethical declaration All procedures performed in studies involving human participants were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare that they have no conflict of interest.

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