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ORIGINAL PAPER

Identifying nutrition-sensitive development options in Madagascar through a positive deviance approach

Arielle Sandrine Rafanomezantsoa[1,3] · Claudia Coral[2,3] · Narilala Randrianarison[1] · Christoph Kubitza[4] · Denis Randriamampionona[1] · Harilala Andriamaniraka[1] · Stefan Sieber[3] · Sarah Tojo-Mandaharisoa[1,3] · Jonathan Steinke[3,4]

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Abstract

Context-adapted interventions are needed to alleviate the burden of food and nutrition insecurity on resource-poor rural households in southeastern Madagascar. The Positive Deviance approach implies identifying locally viable development solutions by focusing on particularly successful, innovative individuals. To identify promising practices that could be promoted as part of food and nutrition security (FNS) interventions in the Atsimo Atsinanana region of southeastern Madagascar, positive deviance was searched among smallholder farmers. Positive deviants are defined as households with overall optimal performance across four aspects of FNS: household-level food security, women's diet quality, child's diet quality, and low diarrhea incidence. To identify positive deviants, a two-step procedure was followed. Based on quantitative survey data from 413 rural smallholder households (mother-child pairs) with a child aged between 6 and 23 months, each household's four performance scores were adjusted by removing the average effects of household resources. Then, households with Pareto-optimal performance were identified regarding the four aspects. Subsequently, 16 positive deviants were revisited and positive deviant practices were identified through in-depth interviews. A set of practices were validated through focus group discussions with local nutrition and agriculture experts. Positive deviant practices include the adoption of agricultural innovation, such as new cash crops, as well as nutrition-sensitive market behaviors and reliance on off-farm activities. In addition, some ethno-cultural factors help to explain positive deviance. These diverse positive deviant practices may serve as examples and inspiration for locally grounded development interventions targeting FNS in southeastern Madagascar.

Keywords Positive deviants · Atsimo Atsinanana · Nutrition · Food security · Madagascar

1 Introduction

Much of the world's population lacks consistent access to safe, nutritious, and sufficient food (FAO, IFAD, UNICEF, WFP, and WHO, 2022). In sub-Saharan Africa, about one in five persons was undernourished in 2020 (FAO, IFAD, UNICEF, WFP, and WHO, 2022). Madagascar is among those countries with the highest rates of food insecurity and malnutrition worldwide. In the southern regions of the island, a drought lasting three consecutive years – 2019, 2020, and 2021 – created a severe nutritional crisis, leaving 28% of children under the age of five acutely malnourished, a third of whom are severely malnourished with a high risk of death (Makoni, 2021). In 2021, an estimated 1.14 million people in southern Madagascar were facing acute food insecurity (IPC, 2021). Several regions of southern Madagascar

Arielle Sandrine Rafanomezantsoa and Claudia Coral contributed equally to this work.

✉ Claudia Coral
claudia.coral@hu-berlin.de

[1] Department of Tropical Agriculture and Sustainable Development, Ecole Supérieure des Sciences Agronomiques Ankatso, University of Antananarivo, Antananarivo, Madagascar

[2] Agrifood Chain Management, Department of Agricultural Economics, Humboldt-Universität zu Berlin, Berlin, Germany

[3] Sustainable Land Use in Developing Countries, Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, Germany

[4] Department of Crop and Animal Sciences, Urban Ecophysiology of Plants, Humboldt-Universität zu Berlin, Berlin, Germany

have some of the highest prevalence of child stunting worldwide (Galasso et al., 2019).

Negative feedbacks within food systems, between agro-ecological and socio-economic limitations, including poverty, weak governance, and political instability, can reinforce food insecurity (Golden et al., 2021; Gebre et al., 2021). This situation is termed a Social-Ecological Trap (SET) in the literature (Brinkmann et al., 2021; Hänke et al., 2017). Some of the most affected regions, including the Atsimo Atsinanana region in southeastern Madagascar, have been subject to humanitarian interventions, including emergency food distribution (IPC, 2021) and World Bank emergency loans, in order to restore and preserve basic service delivery after the economic and political crisis of 2009–12 (Galasso et al., 2019). Although these interventions sought to support the affected populations to cope with immediate shocks, they generally do not sustainably improve the long-term health and nutritional situation. Some research on SETs in Madagascar already exists, having identified possible strategies and interventions that could lower the poverty rate in the long term (Brinkmann et al., 2021; Hänke et al., 2017).

Intervention programs focusing on food and nutrition security (FNS) have been implemented in Madagascar by governmental, non-governmental, and civil society organizations, as well as through multi-stakeholder partnerships (Konzack et al., 2020). Public–private cooperation has achieved progress on food fortification, such as the now-widespread iodine enrichment of table salt (Goh, 2002; UNICEF, 2021) or moringa-based bio-fortified food supplements (Lazaniriana et al., 2020). However, nutrition-sensitive agricultural interventions could improve FNS, since 95% of the population facing acute food insecurity in southern Madagascar depend on agriculture, livestock, and fishing (FAO representative in Madagascar cited in Makoni, 2021). This is reflected by ongoing efforts to replace traditional crop varieties with improved varieties, to diversify farming systems with new crops, and to improve local agricultural skillsets to increase the productivity of smallholder farming (Konzack et al., 2020).These experiences highlight the need for a two-pronged approach to mitigate food and nutrition insecurity, combining supportive context-specific policy (e.g., to improve market access) and immediate, on-the-ground interventions that alleviate the burden of food and nutrition insecurity on resource-poor rural households. However, interventions must suit the local context: too often, generic on-farm innovations fail to be adopted or deliver benefits (Pannell et al., 2006; Giller et al., 2009; Corbeels et al., 2013; Anderson & D' Souza, 2014). As observed by Apraku et al. (2021), who reviewed studies on climate change coping strategies and adaptation mechanisms in Africa, interventions often lack local specificity, rarely focusing on how locally-specific knowledge and practices can help communities cope with the effects of adverse environmental conditions on their agriculture. Another reason for limited adoption and small effects of interventions is the emergence of trade-offs between different household objectives. For example, interventions aiming to increase farm productivity can affect the availability of leisure time (Ditzler et al., 2019) or may increase production risks (Paul et al., 2020). To maximize impacts, development stakeholders need to identify intervention options that minimize trade-offs, hence enabling gains in FNS at minimal cost to other relevant aspects.

Unlike traditional 'top-down' approaches to development that are often not sustainable, approaches that stimulate learning and behavioral change by beneficiary groups may offer more promising results (Albanna & Heeks, 2019). Scaling indigenous, local solutions may increase adoption, as these solutions are developed from local experience gained over time and are adapted to local culture and environment (Makate, 2020). Indigenous people's strategies and local solutions, including women-led innovation for food and nutrition, can contribute to building cross-sectoral coherent and sustainable approaches to food systems (FAO, IFAD, UNICEF, WFP, and WHO, 2022).

The *Positive Deviance* approach aims to identify locally developed and tested solutions to development challenges (Lapping et al., 2002; Marsh et al., 2004; Pant & Odame, 2009). The approach focuses on individuals within a community who show outstanding livelihood performance and who have developed creative and new solutions to address inherent risks and limitations in their livelihoods. Importantly, these 'positive deviants' face the same limitations (resources, infrastructure, climate) as their neighbors, but follow strategies that allow them to achieve better outcomes. Developed initially by nutrition researchers (Marsh & Schroeder, 2002; Marsh et al., 2004) and with a history in health-related research (Bradley et al., 2009; Feng et al., 2016), the Positive Deviance approach is increasingly used within international development research. It can reduce the dependence on external expertise while relying on local resources and know-how (Albanna & Heeks, 2019). Examples include agricultural development (Steinke et al., 2019), farming system redesign (Toorop et al., 2020), and environmental stewardship in artisanal mining (Schwartz et al., 2021).

The objective of this study is to identify unique behaviors and practices that explain outstanding FNS performance among 'positive deviant' smallholder farmers in the Atsimo Atsinanana region of Madagascar. That these practices can be found in local context suggests that they may be useful inputs for locally suitable FNS interventions. They may have greater adoption potential and require smaller changes in mindset. In Section 2, we describe our methodology to identify positive deviant households and positive deviant practices. Section 3 presents identified practices and discusses their potential for nutrition-sensitive development in

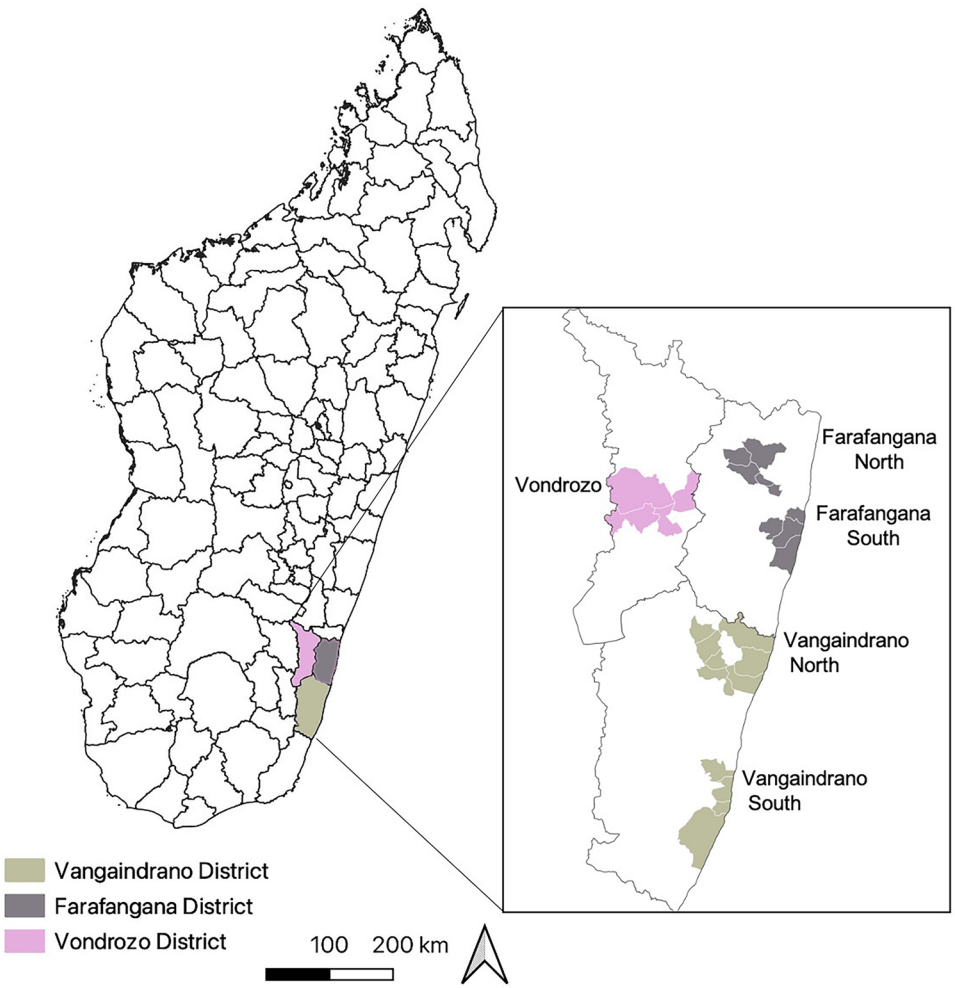

Fig. 1 Map of Madagascar with research areas highlighted

the study region. Section 4 provides a critical reflection of our methodology, and Section 5 concludes with recommendations for local development practice.

2 Methodology

2.1 Research area

The Atsimo Atsinanana region is located in southeastern Madagascar. The region enjoys a hot and humid tropical climate with a monthly temperature average varying from 21 to 24 °C, and approximately 2.000 mm of annual rainfall, mostly during the months of December to July (Randrianarison et al., 2020, using data from 1994–2014). It is frequently affected by cyclones and flooding (CREAM, 2013; FEWS NET, 2021). Agriculture is characterized primarily by resource-poor small-scale farming, focusing on rice, yams, sweet potatoes, and breadfruit. Most farming households keep livestock, including poultry, pigs, and cattle. The Atsimo Atsinanana region experiences acute food insecurity with an IPC (Integrated Food Security Phase Classification) ranging from phase 3 (high) to phase 2 (stressed) for the two districts of Vangaindrano and Farafangana (IPC, 2021). Our research areas are located in three districts: Vangaindrano and Farafangana, which extend mainly on the littoral part, and Vondrozo, a rather hilly inland district (see Fig. 1).

2.2 Identifying positive deviants by quantitative research

2.2.1 Overview of the approach

In this study, positive deviants are households with overall optimal performance across four aspects of FNS, including: (1) Household-level food security, measured by the food insecurity experience scale (FIES); (2) The mother's diet quality, measured by a modified women's dietary diversity score (WDDS), employing the food groups of minimum dietary diversity for women (MDD-W); (3) The child's diet quality, measured by the minimum acceptable diet criterion (MAD); and (4) Physical absorption of nutrients, proxied by the relative frequency of diarrheal episodes of the child (see Table 1).

Table 1 List of performance indicators and control variables

	Type of variable and range	Description	Reference
Outcome variables			
Food insecurity experience scale (FIES)	Count (0 to 8)	Instrument for measuring access to adequate food at the household level, based on people's responses to eight yes/no questions about the previous 30 days and nights. The questions focus on food-related behaviors and experiences associated with increasingly challenging access to food.	FAO, 2016; Smith et al., 2017; Saint Ville, 2019; Pereira et al., 2021
Women dietary diversity score (WDDS)	Count (0 to 10)	Assesses the mother's diet quality by counting the number of (pre-determined) items out of ten food groups that had been consumed by the mother the day preceding the survey (24 h recall). For the purposes of this research, we used the ten food groups of minimum dietary diversity for women (MDD-W).	FAO & FHI 360, 2016; FAO, 2021
Minimum acceptable diet (MAD)	Binary (yes or no)	Assesses the dietary quality of infants and young children by combining a minimum diet diversity criterion and a minimum meal frequency criterion.	WHO, 2008, 2010; Baye & Kennedy, 2020; Ariyo et al., 2021, Picchioni et al., 2021
Diarrhea incidence	Continuous (0 to 1)	Proxies the physical absorption of nutrients by the relative frequency of diarrheal episodes in children since birth (estimated number of diarrheal episodes divided by days of life). A diarrheal episode was defined and explained to survey respondents as "three or more watery of loose stools within 24 h".	Moore et al., 2010; Checkley et al., 2008
Control variables			
Mother's education level	Years of education (0 to 17)	The mother's level of education provides human and social capital and can allow easier acquisition of distinct skills.	Aslam & Kingdon, 2012; Mutisya et al., 2016
Domestic assets	Count (0 to 3)	Telephone, radio, and TV represent not only the household's material resources but also provide them with access to information.	Silvestri et al., 2015
Travel time to the closest market (one way)	Five ordered categories	Proxies households' market access by measuring travel time both for selling farm produce and purchasing diverse food items. Closer markets reduce transaction costs and are often associated with better FNS outcomes.	Wichern et al., 2018; Frelat et al., 2016
Travel time to the nearest water source (one way)	Three ordered categories	Proxies households' access to clean drinking water by the required travel time to reach the water source. Easier access to drinking water may contribute to better hygiene and lower diarrhea incidence.	Pickering & Davis, 2012
Access to farmland	Binary (yes or no)	Whether households have access to farmland managing their own production, in contrast to generating income as landless laborers. Net returns from managing own farmland are generally higher than returns from paid farm work.	Verkaart et al., 2018

Table 1 (continued)

	Type of variable and range	Description	Reference
Woman-headed household	Binary (yes or no)	The gender of the head of household can influence the FNS situation, as women may experience weaker access to agricultural inputs and extension services, and may have lower bargaining power than men when selling farm outputs.	Doss, 2018; Mason et al., 2015
Number of household members	Count (2 to 24)	A larger household size can put pressure on the distribution of available resources and income, contributing to a worse FNS situation.	Bashir & Schilizzi, 2013
Nutrition advice	Binary (yes or no)	Whether the household has received nutrition advice from local health services	Kuchenbecker et al., 2017
WASH advice	Binary (yes or no)	Whether the household has received water, sanitation, and hygiene (WASH) advice from local health services	Morse et al., 2020
Sub-region	Five categories	By accounting for the sub-region, we control for biophysical macro-characteristics such as soil type and climate, which can be important determinants of agricultural performance.	
Livestock farming	Binary (yes or no)	Whether the household owns any livestock, an important asset that can serve to buffer shocks	Frelat et al., 2016

To identify these multi-dimensional positive deviants, the two-step procedure suggested by Steinke et al. (2019) was followed. First, quantitative survey data were collected and each household's four performance scores were adjusted by removing the relative effects of household resources on performance (for details, see Section 2.2.3). The reason for this step is that we were looking for outstanding performance that is due to (innovative) household behavior, rather than better access to resources. Second, households with Pareto-optimal performance were identified regarding the four aspects. This focus on Pareto-optimality was adopted to identify households that cope successfully with trade-offs between different household objectives (e.g., regarding expenditures on caloric energy, dietary diversity, or hygiene articles).

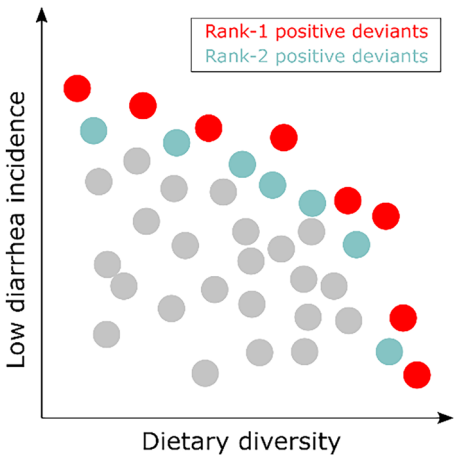

Fig. 2 Simplified illustration of the Pareto-optimum concept (two dimensions, only). Each dot represents a surveyed household. Positive deviants (red) are not necessarily superior to non-positive deviants (grey) in every individual dimension. However, all positive deviants achieve optimal *overall* outcome. Rank-2 positive deviants (green) can be identified after removing rank-1 from the sample

2.2.2 Household survey

Quantitative survey data was collected from 413 rural households (mother–child pairs) with a child aged between 6 and 23 months (underlying dataset in Annex A). Households were selected through a three-stage random sampling process. First, 24 communes were selected, then 67 districts (fokontany). Lastly, in each district, between 6 and 7 mother–child pairs were randomly surveyed using a structured questionnaire. The questionnaire included modules on socio-economic household characteristics, mother and child diets, household food security, and the farming system (see Table 1).

2.2.3 Addressing the influence of household resources

Within the survey population, there was substantial heterogeneity regarding resources that can influence the FNS situation, such as livestock assets or education. To identify positive deviants, we sought to make households more comparable by removing the average influence of individual household resources on the FNS situation. Separately, for each indicator, regression models were employed using eleven household resources as covariates (see Table 1). These covariates were selected based on available data and the empirical literature on common determinants of FNS. For FIES, the raw count of positive answers was used as the dependent variable, rather than transforming this score into fewer, broader categories. This was done to avoid overlooking even minor differences between households. Both FIES and the relative frequency of diarrheal episodes were inverted to ensure a higher score represents a better situation, in line with WDDS and MAD. For FIES, WDDS, and the relative frequency of diarrheal episodes, linear regressions were employed. For MAD, a logistic regression was used.

From each of the four regressions, the residuals for each household were extracted. Residuals represent the positive or negative deviation from the predicted outcome (e.g., WDDS score, or probability of MAD) based on the individual's covariate space, i.e., the household's resources. As the residuals represent unexplained variation in FNS performance after accounting for resources, they are likely to represent, in part, differences in household behavior. Using the residuals, four 'relative' FNS scores per household were obtained. Lastly, to make the scores comparable, the four distributions of residuals were standardized by z-transformation. That is, from each value, the sample mean was subtracted and then divided by the sample standard deviation. This resulted in equal means and standard deviations for the four distributions without changing relative differences within the distributions.

2.2.4 Identification of positive deviant households

The criterion of Pareto-optimality implies strongest possible overall performance without giving normative preference to any of the four indicators chosen (Groot et al., 2012; Modernel et al., 2018). That is, positive deviants are those households that achieve the best overall performance in FIES, WDDS, MAD, and (low) diarrhea incidence, corrected for the mean influence of household resources. Figure 2 provides a simplified illustration of the Pareto-optimum concept. Pareto-optimal relative households' performances were identified using the *emoa* package (Mersmann, 2020) in the R software (R Core Team, 2020). To increase the number of positive deviants, rank-1, rank-2, and rank-3 Pareto-optimal performers were included. Rank-2 positive deviants were identified by removing rank-1 from the dataset and identifying Pareto-optimal performers again. The same procedure was used to identify rank-3 Pareto-optimal performers. Systematic differences between the group of positive deviants

and other households were identified by exploring available survey data, using Student's t-tests and Chi-squared tests.

2.3 Identifying positive deviant behaviors by qualitative research

2.3.1 Interviews with positive deviant households

Of 22 positive deviants identified in the previous step, 16 were available for a re-visit and extensive interview. Semi-structured interviews were conducted, lasting between one and two hours, intending to identify potentially uncommon practices that offer plausible explanations for their superior FNS outcomes. The semi-structured interviews included questions related to market access, market dynamics, dietary habits, livestock production, behavior related to water and sanitation, agricultural practices, and income generating activities (full interview guide in Annex B). The interviews were recorded and transcribed. In addition, we visited the surroundings of each positive deviant's homestead and, where possible, at least one farming plot together with the positive deviant. Observations were documented, particularly regarding farming practices. Data were analyzed inductively, allowing the establishment of provisional categories of positive deviant practices.

2.3.2 Verifying hypothesized positive deviant practices with local experts

To narrow down which identified practices can indeed be considered uncommon or 'deviant' and discuss possible effect pathways, six focus group discussions (FGDs) were organized, each with between five and eight local nutrition advisors (*ACN, agents communautaires de nutrition*). Local nutrition advisors are trained to ensure that nutritional messages are well received by beneficiaries and translated into behavioral change in households and communities. Besides, they have general expertise in agricultural practices and are familiar with local livelihoods. In each FGD, all previously identified practices that were hypothesized to be uncommon were briefly presented and discussed. As a result, certain practices were validated as positive deviant practices.

3 Results and discussion

3.1 Characteristics of positive deviant households

Positive deviants are identified in all three districts; no single district is overrepresented. Twenty-two positive deviants were identified, corresponding to about 5% of all surveyed households. Overall, positive deviants are younger, more likely to treat their drinking water, show significantly higher rates of consuming certain food items, have more diverse off-farm income sources, and more frequently visit the market. Table 2 shows an overview of selected differences in survey data between positive deviants and other households. Table 3 shows the mean standardized magnitude of positive deviance by performance indicator. Positive deviants deviate from expected performance most strongly regarding FIES and least strongly for diarrhea incidence (Table 3).

3.2 Positive deviant behaviors

3.2.1 Underlying principles

Through empirical research with positive deviant farming households in Madagascar, we observed multiple behaviors and household characteristics that plausibly contribute to the households' superior FNS situation. These are presented in detail in Sections 3.2.2 to 3.2.5. Underlying these behaviors, we identify three basic principles associated with successful smallholder livelihoods: diversification of livelihoods (e.g., adopting new crops or emphasizing off-farm activities), adaptation to climate change (e.g., switching crop varieties or renewing tree plantations), market integration (e.g., selling horticultural products or avoiding 'buy high, sell low' dynamics). In addition, some behaviors seem associated with nutrition-sensitive dietary decision-making, such as choosing to eat eggs over selling them. Our findings are in line with existing research that tends to attribute positive deviance in farming to risk reduction through diversification, adaptation, and harnessing complementarities among livelihood practices (Pant & Odame, 2009; Steinke et al., 2019; Toorop et al., 2020; Ulukan et al., 2022).

Although our discussions with local experts confirmed that all behaviors were rather uncommon (not practiced by the majority of households overall), few of these behaviors seem entirely exclusive to positive deviants. Feedback from local experts suggested that positive deviants, compared to other households, were either more consequent or meticulous in implementing them (e.g., adoption of agricultural innovation, Section 3.2.2) or practiced them more intensely, on average (e.g., off-farm activities, Section 3.2.4). Moreover, while most of these behaviors can be found in other households, too, many positive deviants showed multiple of the identified behaviors. This multiplicity of deviant behaviors practiced by positive deviants in our sample likely interacts in complementary ways, contributing to an overall deviant livelihood.

3.2.2 Adoption of agricultural innovation

Cultivation of new cash crops Seven positive deviants cultivate cash crops with high market potential, including

Table 2 Overview of survey data. Percentages or mean and standard deviations (in parentheses) are shown, as appropriate. P-values are of t-tests of Pearson's Chi-squared test, as appropriate

	Positive deviants	Other households	p-value
Number of observations	22	391	
Mother's age	23.1 (5.2)	26.6 (7.3)	**
Water treatment	95%	74%	*
Women's diet			
Grains, white roots, plantains	100%	99%	
Pulses	14%	9%	
Nuts and seeds	0%	2%	
Dairy	18%	4%	*
Meat, poultry, fish	68%	31%	***
Eggs	9%	1%	*
Dark green leafy vegetables	77%	72%	
Other vitamin A-rich fruits and vegetables	41%	11%	***
Other vegetables	18%	12%	
Other fruits	32%	25%	
Child's diet			
Grains, roots and tubers	95%	99%	
Legumes and nuts	18%	11%	
Dairy	18%	8%	
Meat, poultry, fish, or offal	55%	26%	**
Eggs	9%	2%	
Vitamin A-rich fruits and vegetables	68%	43%	*
Other fruits and legumes	36%	31%	
Livelihoods			
Regular salary	14%	5%	
Number of off-farm activities	1.6 (0.8)	1.4 (0.8)	
No off-farm activities	9%	13%	
1 off-farm activity	32%	44%	
2 off-farm activities	45%	34%	
> 2 off-farm activities	14%	9%	
Livestock holdings (TLU[a])	1.35 (2.06)	1.01 (2.00)	
Market frequency			**
Going to market everyday	41%	26%	
Going to market on a weekly basis	59%	66%	
Going to market on a monthly basis	0%	8%	
Having vegetable garden	55%	42%	
Growing vegetables (anywhere)	100%	93%	
Number of chickens sold during the last 12 months	7.11 (7.48)	6.07 (9.58)	
Number of eggs sold during the last week	0.58 (2.42)	1.21 (9.71)	
Number of poultry	19.76 (17.76)	11.67 (2.60)	

[a]Tropical Livestock Units (Njuki et al., 2011)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

vanilla, cloves, and corrosol (*Annona muricata* L.). Vanilla and cloves are gaining popularity due to their high market price, with positive deviants being among the first adopters, as one positive deviant explains, "*these last 4 or 5 years, they (vanilla and cloves) are trendy here, in our region. Coffee has been here for a long time now….*" Corrosol, also called soursop, is an exotic commodity that is finding its way into commercial markets (Sanusi & Abu Bakar, 2018). As one positive deviant explains, a large fruit sells for about 2,000 ariary (roughly US$ 0.50) per unit, which motivates households to grow it. Although crop choice is not alone motivated by its market price, our results suggest that the market price influenced the decision to produce and commercialize certain, uncommon, high value crops.

Table 3 Magnitude of positive deviance by performance indicator. A value of 1 corresponds to one standard deviation above the predicted score

Performance indicator	Mean standardized residual
FIES	1.56
WDDS	1.28
MAD	1.28
Low diarrhea incidence	0.52

Early adoption of new crops, crop varieties and value chains Two positive deviants experiment with, so far, uncommon agricultural activities. Development projects have introduced many of these activities to the study region and positive deviants are among the first to adopt new crops and agricultural technologies. These positive deviants engage in beekeeping and in planting red beans and short-cycle sweet potatoes, all of which are relatively new activities in the region. These findings seem to suggest two things: first, some externally introduced innovations are proven viable in the local context, resulting in improved FNS outcomes. Second, some positive deviants seem to be early adopters of these introduced innovations. Although it is difficult to assess the extent to which these introduced innovations are external or based on locally developed promising practices, these findings highlight that introducing novel value chains through development projects may indeed lead to positive change among targeted farmers. These value chain interventions were accompanied by guidance on agronomic management, nutrition education, market development, and/or market information. However, optimal adaptation and development pathways vary for different types of farmers and are location-specific (Stringer et al., 2020). In this regard, crop priority setting may be required to balance food use with market needs, thus acknowledging the behaviors and preferences of both producers and consumers. An emphasis by development organizations on highly nutritious 'orphan' crops may help (McMullin et al., 2021). Social learning and farmer-participatory prioritization of new value chains may help to enhance farmers' knowledge and confidence for effective scaling processes (Nelson et al., 2019).

Trying new crops or switching to a new variety bears risk, but better outcomes can reward this risk-taking in the long run. Encouraging farmer entrepreneurial orientation may play a role in implementing nutrition-sensitive development interventions. Several studies demonstrate the importance of entrepreneurship for the success and well-being of farmers. Development organizations can foster an environment conducive to farmer entrepreneurship, for example, by facilitating market transactions and access to credit, as well as integrating entrepreneurship knowledge in farmer trainings (Kangogo et al., 2021).

Fig. 3 Cloves nursery of one positive deviant household

Renewal of tree plantations Many fruit trees, including litchi and mango trees, were planted by parents or ancestors, near their homesteads, and their descendants continue to benefit from the fruits. However, five positive deviant households have recently planted fruit trees in addition to the trees that were already present. This practice may partly explain the elevated consumption of vitamin-A-rich fruits among positive deviants (see Table 2). One positive deviant also maintains a tree nursery, generating income from selling tree seedlings (see Fig. 3).

In parallel to the trend toward planting cloves in eastern Madagascar, Michel et al. (2021) also observe diversification with associated tree species (fruit trees in particular) and increased agroforestry-style intercropping with banana, pineapple, sugar cane, or rainfed rice. As Michel et al. (2021) conclude, tree plantations bear great potential for the production of fruits, rainfed rice, and fodder resources, but stronger commercialization of these products is needed. Our results suggest that the active renewal and diversification of farmers' tree resources may contribute to better FNS outcomes in the study area by contributing to a diversified diet and providing additional income.

3.2.3 Nutrition-sensitive market behaviors

Women and children in positive deviant households are more likely to consume animal-source food (dairy, meat, eggs), suggesting that the higher score in FIES, WDDS, and MAD are, in part, driven by greater access to these particular food groups (Table 2). That positive deviants do not maintain significantly

higher livestock assets, but are significantly more likely to consume livestock products (instead of selling them) supports the idea that positive deviants have greater awareness of the role of animal protein in diets. Behavior change interventions targeting increased home consumption of livestock products have been shown to effectively improve dietary outcomes of smallholder households (McKune et al., 2020; Waters et al., 2018). Our results about positive deviants suggest this could be a viable option in Atsimo Atsinanana.

Although our analysis controls for travel time to the market, we find that positive deviants, overall, visit the market more frequently than other households (Table 2). Positive deviants are more likely to cultivate vegetables, such as eggplant, cucumber, and zucchini (data not shown), then likely generate income from selling these at the market. Frequent market access is key to achieving high sales prices for perishable vegetables. Market access could be improved, for example, by investing in public infrastructure in strategic areas and by better integrating remote households into market environments (Hochard & Barbier, 2017). Farmer cooperatives or groups can be incentivized to set up markets and women could receive coupons to redeem at the market.

Two positive deviants state that they anticipate seasonal fluctuations in rice market prices and adapt their behavior accordingly. At harvest time – when prices are low because many farmers intend to sell immediately – these positive deviants avoid selling. In some cases, they even invest in buying rice from their neighbors and storing it. In this way, the positive deviants minimize the need to buy rice during the lean season, when most farmers' own rice stocks are running low and the market price is high. Sub-optimal post-harvest decision-making is widespread among smallholder cereal farmers (e.g., Ruhinduka et al., 2020). Development organizations, however, can support farmers to avoid selling rice at minimal prices, for example, by enhancing safe storage capacities (De Groote et al., 2013) or enabling easy access to small credits (Burke, 2017; Kadjo et al., 2018).

3.2.4 Off-farm activities

Compared to other households, the off-farm activities carried out by positive deviants are relatively remunerative, allowing them to ensure their family's food security and diversify their diets. Positive deviants are, for example, engaged in cash crop collection and masonry, or receive a permanent salary as a community health agent, radio host, or security guard. Off-farm activities allow them to supplement the limited quantity of their own harvests with purchased food. Access to off-farm income is identified as an important driver of superior FNS outcomes in vulnerable, resource-poor farming environments (Fraval et al., 2019; Frelat et al., 2016), especially in areas with climatic and price variability (Dzanku, 2019; Wossen & Berger, 2015). Davis et al. (2017) argue that diversifying income sources beyond farm income may function as a household strategy to manage climatic risk and overcome market failures. Other studies suggest that the income generated from off-farm activities is partially reinvested in the farm, for instance for purchasing inputs (Adjognon et al., 2017).

Not all farmers, however, have access to a remunerative job alongside their farming activities. Social capital and attitudes about farming play an important role in the search for non-farming income sources (Van den Broeck & Kilic, 2019; Verkaart et al., 2018). Moreover, as one positive deviant explained, additional benefits of off-farm activities include access to others' land for cultivation. Because her spouse works as a security guard for a larger property, the household is granted access to additional land for cultivation. Overall, off-farm activities that ensure financial stability constitute a strategy to achieve better FNS outcomes in vulnerable environments, especially when part of the income is reinvested in the farm.

3.2.5 Cultural explanations

Living as part of parents' household Four positive deviants explained their superior performance by their dependence on their parents, who allow them to co-benefit from the parents' productive resources. Two of these positive deviants stated they did not own land and did not make autonomous decisions regarding their income and daily activities. Although they lived in their own houses next to their parents, they shared the same food with parents and siblings, thus behaving as one large household. This living arrangement as a 'macro-household' gives these positive deviants access to resources, such as land and knowledge, originally accumulated by the parents. In the other two cases, the positive deviants pursued a strategy of building up their own resources while taking advantage of their parents' resources. As one positive deviant explained, the young couple is initially living with their parents, building up their own resources. Once their own resources are sufficient, they plan to leave their parents' house and live independently.

In both cases, positive deviance may be explained by economies of scale, as the labor of all family members can be allocated efficiently across all operations on the parents' farm. In addition to more effective use of farm resources and a resulting better FNS situation, a possible explanation for positive effects on diarrhea incidence may be that the grandparents can share experiences and know-how about childcare. Family structures, including the different relations and responsibilities of family members, can be linked to food security. They play a crucial role in the development of eating habits though socialization and parental modelling

(Briones Alonso et al., 2018). Some studies find a significant influence of living arrangements on the food security of students in Turkey, children in the USA, or Palestinian refugees in Lebanon (Balistreri, 2018; Niyaz, 2021; Sahyoun, 2020). These results show potential for future research on the relationship between living arrangements, knowledge systems, resources, and FNS.

Transmission of traditional dietary knowledge In the study region, in most cases, the mother makes daily dietary decisions for the household. One positive deviant woman had migrated from the highlands when she married a resident of Atsimo Atsinanana. Since the culinary culture in the highlands typically involves more vegetables in the diet, these eating habits might imply a greater willingness to invest in a diverse diet in the study region as well. A growing body of literature seeks to understand the role of traditional dietary knowledge (Briones Alonso et al., 2018; Trichopoulou et al., 2007). It is recognized that diets are influenced by past habits, future insecurities, as well as current socioeconomic and health status (Govindaraju et al., 2022). Knowledge on dietary diversity and locally uncommon cooking habits could be shared via existing communication networks, for instance, through local nutrition advisors.

4 Methodological reflections

The Positive Deviance approach implies a mix of research methods, selecting interview respondents through a highly systematic procedure. Such informed, statistical selection of research participants, rather than random sampling, may increase the robustness and replicability of results. In turn, however, it means that the specific design of quantitative data collection eventually influences who is identified as a positive deviant. One limitation of our quantitative survey is that access to farmland was measured as a binary variable, which does not reflect the full complexity of customary land tenure systems in Madagascar. It is observed that most positive deviant households own land, while others do not own land but benefit from using others' farmland. These two strategies may imply substantially different asset levels. In the same vein, measuring market distance by travel time to the nearest marketplace does not capture the fact that mobile street vendors also sell certain products in the villages. For some respondents, this improves access to diverse food items.

Gender roles and family relations are closely linked to decision-making power that ultimately affects food security (Briones Alonso et al., 2018). Our results show that some positive deviant practices are more gender-sensitive than others. For example, in most cases, women manage the family's diet. Off-farm activities, however, are typically pursued by the male head of the positive deviant household. Prior to promoting the uptake of off-farm activities, a thorough analysis of gendered decision-making in local households may help to identify pathways through which increased family income effectively translates into improved dietary outcomes.

5 Conclusions

This study identifies specific sets of practices and behaviors that can explain outstanding food and nutrition security performance, and that could be promoted to other farmers. These positive deviant practices are expected to have high adoption potential and transferability, as they are grounded and demonstrated in the local context. The identified positive deviant practices include nutrition-sensitive market behaviors, agricultural innovation, such as the adoption of uncommon crops or the renewal of tree plantations, as well as generating income from off-farm activities. This diversity suggests that despite heterogeneity in assets and farm types, many local households may be able to adopt a positive deviant behavior. As a next step, for development organizations employing the Positive Deviance approach, enabling an informed choice and targeting the most suitable options to heterogeneous households will likely be key. As part of a locally grounded approach to development, positive deviant behaviors could serve as inspirations, rather than rigid blueprints. Existing communication networks, such as farmer field schools or community nutrition advisors, may be crucial in helping farmers identify individually suitable, practical solutions based on the validated sets of positive deviant behaviors.

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Author's contributions ASR and JS conceptualized and designed the study. ASR carried out fieldwork with support from STM. ASR, CC, CK, and JS performed data analysis and interpretation. ASR, CC, and JS wrote the original draft and NR, CK, DR, HA, StS, and STM contributed to the manuscript development. StS administered the project.

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Data availability The full household survey dataset used for the identification of positive deviants can be found in Annex A.

Declarations

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

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Arielle Sandrine RAFANOMEZANTSOA is a Ph.D. student at the university of Antananarivo, Madagascar. She has a background on food science and technology. As a Master's student, she contributed to investigating the causes of child malnutrition and poor development in Vakinankaratra region of Madagascar. Currently, her research focuses on the household food security improvement in the southeastern region of Madagascar.

Claudia CORAL has a background in integrated management of natural resources and a Ph.D. in Agricultural Economics at Humboldt-Universität zu Berlin. Her current research focuses on understanding political, institutional, socio-cultural, and economic factors affecting value chains' and food system's functioning and development, including food security. She is currently developing research at the Agrifood Chain Management department at Humboldt-Universität zu Berlin and the Leibniz Centre for Agricultural Landscape Research (ZALF).

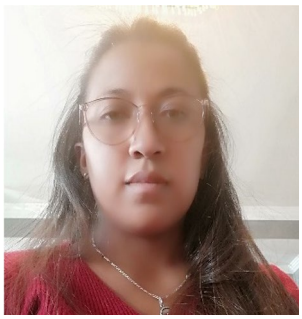
Narilala RANDRIANARISON is a lecturer at the Higher School of Agricultural Sciences (ESSA), University of Antananarivo. He is an agricultural engineer and he did his PhD study in economics at the University of Montpellier 1, France. His research priority areas are agro-economics, value chain analysis, sustainable development and food security.

Christoph KUBITZA is a research associate in agricultural and development economics at Humboldt University of Berlin and the German Institute for Global and Area Studies. He received his PhD in agricultural economics from the University of Goettingen within a collaborative research center (CRC 990 funded by Deutsche Forschungsgemeinschaft (German Research Foundation)) where he continued as a senior research fellow studying land-use change in Indonesia and its economic, institutional and demographic effects. He worked also as consultant for several *CGIAR* Research Centers. His major research interests include the economic and social impacts of land-use change and global land acquisitions as well as technology adoption in smallholder farming in low-income countries.

Denis RANDRIAMAMPIONONA is a lecturer in the University of Antananarivo, Ecole Supérieure des Sciences Agronomiques (ESSA), Mention Agriculture Tropicale et Développement Durable (AT2D). He obtained his doctoral degree at the University of Antananarivo in collaboration with the Université Libre de Bruxelles (Belgium). His area of research is plant production. He was particularly interested by valorization and domestication of plant genetic resources in the fields of food, pharmaceuticals and cosmetology.

Harilala ANDRIAMANIRAKA is an Associate Professor at the University of Antananarivo, Ecole Supérieure des Sciences Agronomiques (ESSA) Madagascar, department of agriculture. He is also the director of the Doctoral School "Agriculture-Livestock-Environment". He has an expertise on phosphorus, fertilizers, soil fertility and cropping systems. His research focuses on natural risk management and soil sciences.

Stefan SIEBER is an Associate Professor (PD, Privatdozent) at Humboldt University zu Berlin and concurrently he coordinates the department SusLAND "Sustainable Land Use in Developing Countries" at the Leibniz Centre for Agricultural Landscape Research (ZALF). His domains are food security and nutrition, climate change and bioenergy. He focuses on inter- and transdisciplinary research methods such as co-design of innovation, policy and governance analysis. Beyond, he applied sector modelling approaches and further developed impact assessment methods in Europe, Latin America and sub-Saharan Africa. He (co-)coordinated 37 international research projects, authored/co-authored 160 peer-reviewed publications as well as more than 100 conference contributions.



Sarah TOJO MANDAHARISOA is a PhD student in the field of nutrition and food security, at the University of Antananarivo Madagascar. She has a Master's degree on tropical agriculture. Her research is oriented on the improvement of food security status and diet diversification of smallholder farmers in the south-eastern region of Madagascar mainly during lean period.

Jonathan STEINKE is a post-doctoral researcher with Humboldt University Berlin and the Alliance of Bioversity International and CIAT (CGIAR). His research is dedicated to developing inclusive methodologies that empower smallholder farmers to identify, communicate, and scale on-farm innovation. His main interests include trade-offs in agricultural development, participatory design, and digitally enabled participation of farmers and beneficiaries, for example, through farmer citizen science or digital feedback tools. His regional focus has been on Central America and Eastern Africa.