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A rapid realist review of household gardening interventions for improving vegetable consumption in low- and middle-income countries (LMICs)

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Abstract

Background Household gardening is a widely promoted strategy to address low levels of vegetable consumption and improve overall diets in low- and middle-income countries (LMICs). However, existing studies reveal variable effectiveness across different contexts and program designs. This study uses a realist lens to, first, identify three common impact pathways of household gardening interventions from existing literature—production, income and knowledge pathways—and, second, elucidate causal configurations where specific mechanisms are triggered that motivate or demotivate households to follow these pathways of improving vegetable consumption through household gardening. Third, we discuss these findings to provide entrance points to make these interventions more effective in improving vegetable consumption and overall diets.

Results This study applies a Rapid Realist Review of published literature on household gardening in LMICs. A total of 24 studies were found that could be used in developing initial programme theories on household gardening. Using a realist approach to evidence synthesis, a total of 11 programme theories, written as intervention-context-mechanism-outcome (ICMO) configurations, were identified and mapped along the three impact pathways. An expert panel was convened, and key informant interviews undertaken to identify the most impactful and actionable configurations. Various mechanisms underlie the motivation of households to start and maintain household gardening, contingent on specific contextual conditions, such as the opportunity to be food secure and resolve household expenses, individual curiosity and experimental nature, social connectedness, self-efficacy, sense of responsibility, and opportunities for resource sharing and knowledge exchange.

Conclusions This study contributes a deeper assessment of household garden interventions than has previously been available. The various identified ICMOs linked to the three impact pathways can be used in the design of programs to make them more cognizant of social and personal context, and effective in improving vegetable consumption in LMICs. Household gardening programs can consider leveraging multiple intervention components at the individual level, while consciously accounting for constraining personal, household, social and environmental contexts that impact motivation and ability to practice gardening. Continuing research is needed to advance agricultural interventions such as household gardening to improve diets and nutrition in LMICs.

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Background

Multisectoral actions to address high rates of food insecurity and malnutrition across the globe emphasise the role of food system interventions in enabling healthy diets and positive nutrition outcomes [1]. The World Health Organization (WHO) defines a healthy diet as the regular and adequate intake of fruits, vegetables, and whole grains, and the limited intake of foods high in energy, fats, sugars, and salt [2]. However, several barriers to attaining a healthy diet exist. Global fruit and vegetable (F&V) consumption is found to be low on average, but especially among low-income populations [3]. The average per-capita global consumption of F&V is only around two-thirds of the WHO recommendation of 400 g daily, with levels considerably lower in countries in sub-Saharan Africa, Oceania, and Southeast Asia due to factors of availability and price, as well as complex determinants of changing lifestyles, food habits, nutritional awareness, and cultural norms [3, 4].

There is multitude of evidence on the contribution of F&V to achieving the global sustainable development agenda [5]. As a response, various multisectoral action plans to increase F&V production and intake have been developed [6]. The year 2021 was declared by the United Nations (UN) as the International Year of Fruits and Vegetables, which coincides with the UN Decade of Action on Nutrition 2016–2025 and the UN Decade of Family Farming 2019–2028. Further, in the recent 2021 UN Food Systems Summit, the scientific group working on food systems outlined strategies on leveraging the contribution of multiple sectors such as agriculture in enabling fruit- and vegetable-rich diets globally [7].

To date, challenges remain for improving F&V consumption. Global F&V production was found to be insufficient to meet the WHO dietary recommendations [8]. Several push factors on improving F&V production highlighted the need for actions such as diversification of production systems, provision of extension services, and improvement of supply chains and market access at the level of the household and individual; household and community gardening are considered potential strategies that can improve F&V intake [7].

Household gardening

Household gardening is one of the time-tested and widely practised agricultural activities that is considered to have an integral role improving food security and nutrition, especially for smallholder farming households in low- and middle-income countries (LMICs) [9, 10]. Commonly, household gardens are referred to as a small-scale mixed production system that require low capital inputs and are implemented using simple technology. These gardens encompass vegetables, fruits, spices, medicinal plants, and in some cases, livestock. This small-scale production system provides food for own consumption and, for some, a supplemental source of income or a fall-back food source during lean agricultural seasons [11, 12]. Further, household gardens also hold a significant role in preserving local agrobiodiversity and supporting community cohesion [13].

The role of household gardening in food security and nutrition remains relevant and has undergone a resurgence due to experienced limitations of single-crop farming, frequent extreme weather events, and the environmental deterioration caused by productivity-focused forms of agriculture [12, 14]. Galhena et al. [9] distinguish three areas where household gardening is beneficial, beyond the direct nutritional benefits: (1) *social*, (2) *economic*, and (3) *environmental*. Social benefits include enhancing food security and nutrition, uplifting women's status, preserving indigenous knowledge, and improving social capital. Economic benefits involve income generation and improved livelihoods; while environmental benefits include gardening's contribution to nutrient recycling and increased local biodiversity.

Impact pathways of household gardening programs

Household gardening programs are often implemented with supportive services, which may include the provision of inputs such as seeds, water, land tenure, technology, financing, agricultural technical assistance, as well as health and nutrition education and women and community empowerment programs [15]. Rigorous scientific evidence on the impact of such multi-component program on food security and nutrition is sparse. As household gardening is often only one component of a support package, it is difficult to assess its impact due to its function along with other program components, in long program cycles, and with highly varied implementation modalities and sociocultural contexts [16]. Nevertheless, several studies distinguish some generalised pathways in which household gardening programs can enable improved dietary outcomes.

Olney et al. [17] developed a program framework outlining three pathways in which homestead food production enabled improved household consumption of nutrient-rich foods. These pathways include (1) increasing the availability of micronutrient-rich foods through increased household production, (2) improving income through the sale of products from household food production, and (3) increasing knowledge and adoption of nutrition and nutrition-related practices.

Schreinemachers et al. [18] developed an impact pathway for a *'household garden model'* implemented by the World Vegetable Center in LMICs. The pathway highlighted three integrated components of household vegetable production, nutrition and health education, and community support systems as synergistic interventions to increase year-round household F&V consumption. The study emphasised the role of intermediate outcomes within the impact pathway, such as gardening skills, women empowerment, conservation of traditional species, and peer learning among neighbours to increase the impact of household gardening on nutrition.

A conceptual framework that integrates the impact pathways of household gardening from the foregoing studies mentioned [17, 18] was developed and will later be used as a starting point for this realist synthesis (See Additional file 1). Three major pathways can be derived from the framework, namely (1) *production*, (2) *income*, and (3) *knowledge*. Each pathway consists of steps from interventions to outputs and outcomes, and underlying assumptions that can either be affirmed or contested by literature on household gardening programs and related fields.

Existing empirical studies and literature reviews of household gardening programs with integrated supportive interventions on agricultural capacity building and nutrition education report mixed effects on diets and nutrition [16, 19, 20]. On average, they show improvements in vegetable consumption and overall diet but limited effects in areas with adequate market access and more modernised agricultural systems. It is clear that 'average effects' are not very informative and actionable, and more insight in the contextual factors and mechanisms that make household gardening work for some groups and not for others is needed.

Realist synthesis has a focus to provide insights about how program pathways are either enabled or constrained, in achieving desired outcomes, asking 'what works for who, why when and how?' [21, 22]. Given the heterogeneity of evidence, this study aims to give a range of so-called 'middle-range theories' that answer the overarching question of what household gardening interventions work or do not work, for whom, in what context, and how, to improve vegetable consumption in LMICs. Specifically, this study aims to answer the following two sub-questions: (1) What are the impact pathways of household gardening interventions that lead to improved vegetable consumption? and (2) What are the intervention-context-mechanism-outcome configurations (ICMOs) that work within these impact pathways that enable or constrain improved vegetable consumption?

To the authors' knowledge, there is no existing realist review conducted on household gardening in the context of LMICs. The current knowledge base on impact pathways of household gardens is not yet elaborated to describe how they can best facilitate the improvement of dietary outcomes. This gap in the literature further establishes the significance of the study to the field of realist review methods, in addition to its main contribution to advancing the implementation of household gardening for improving food security and nutrition outcomes. Acknowledging and addressing these contextual factors and mechanisms will allow for more responsive program designs that can optimise interventions such as household gardening to result in a sustained positive impact on nutrition.

Methods

Approach

This study uses the Rapid Realist Review (RRR) approach to analyse the evidence and produce relevant insights for policymakers and implementers in an area of study, under conditions of limited time and resources. The RRR is a specific method of realist synthesis, which examines the interactions between context, mechanisms, and outcomes (CMOs) in complex social interventions [23]. We added the concept of 'intervention' (I) to specify to whom the causal explanation relates, and/or which intervention or strategy is related to a particular CMO configuration [24]. Figure 1 illustrates the basic components of the ICMO statements used in this paper.

Interventions (I) change norms and patterns because they trigger mechanisms (M) that motivate some persons or households to change their current condition or ways of doing (social regularity), e.g. livelihood strategies [25]. Mechanisms can then be defined as the reasoning or reactions of individuals or groups in relation to the resources accorded to them through an intervention [21]. Such mechanisms operate within a certain context (C), where context is defined by Pawson et al. [26] as the conditions in which interventions are introduced. Context may pertain to the characteristics of individuals, locations, and social relationships where the intervention is implemented. It is these contexts that interact with or trigger the mechanisms to produce the outcomes. In this research, the intended range of outcomes (O) are the modifications of current practices that could lead to the

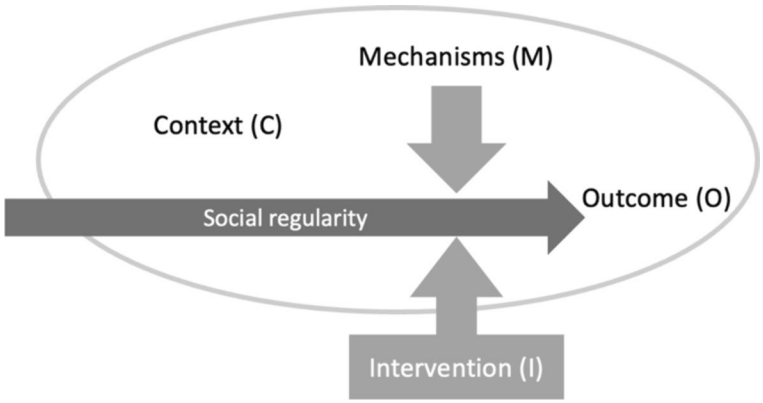

Fig. 1 Basic components of realist causal explanation. Derived from Ton and Vellema [25]

ultimate impact: the maintaining of a household garden and ultimately improved vegetable consumption.

Realist synthesis approaches were developed to respond to the complexity of social interventions and the need for more nuanced views on how interventions result in their intended outcomes and impacts [21]. Conventional review methods such as meta-analysis and systematic reviews generally provide findings focused on linear causation, specifically the regularities and repeated occurrences between specific intervention modalities and their outcomes [27]. Realist synthesis is based on generative causal inference where the focus is not on average effects but on the behavioural mechanisms that are triggered under specific contextual conditions, and that make that an intervention reach its intended outcomes [22]. This evidence synthesis method builds on existing studies and reviews, and takes us deeper into understanding causality.

Data collection and synthesis

The steps in this study draw from the Realist and Meta-narrative Evidence Synthesis: Evolving Standards (RAMESES) publication standards guide [28] and modified to fit the context and available resources of the researcher as advised in literature [23]. The list of report items in realist synthesis according to the RAMESES guide and where these come back in this paper can be viewed in Additional file 2. The steps of the RRR are described in detail as follows:

1. Definition of scope and research questions

The research scope was defined and agreed between the study authors. The two research questions served as the basis for the search and analysis of studies. An initial conceptual framework on household gardening and its component pathways was distilled from existing review studies and has been refined in this review.

2. Identification of documents

Various studies were identified for use in the refining of the initial conceptual framework and in developing programme theories on the impact of household gardening on vegetable consumption. Inclusion criteria for documents adhered to two main criteria, *Relevance* and *Rigour*, as indicated in the RAMESES guide [28]. *Relevance* pertains to whether the study can contribute to building and testing of theories of concern. In this case, any study that related to the implementation of household gardening programs in LMICs and supports inferences of contextual factors, mechanisms, and outcomes on vegetable consumption, was included. *Rigour* refers to whether the method used to generate the relevant information is coherent, credible, and trustworthy. Examples of documents that do not meet the rigour criteria are anecdotal accounts or research findings that do not result from systematic approaches to inquiry or do not contribute to developing programme theories.

The starting point of the identification of studies was a Microsoft Excel database of 1,383 studies published from 2001 to 2019, listed in a scoping study by Harris et al. on vegetables for healthy diets in LMICs [29]. This study had used the same inclusion criteria as described above. These studies were filtered to include intervention studies only; and narrowed down, using the Microsoft Excel search feature, with the following terms: *home garden, household garden*, *kitchen garden,* and *garden*, to explicitly capture the studies on household gardening programs. The studies from the resulting list were retrieved from their source using Scopus, and exported, grouped, and tagged using a data management software (Zotero v. 6.0.9).

Primary screening was conducted by reading the abstract to check for incorporation of household gardening and other information relevant for theory-testing such as pre- and post-intervention outcomes of the program. After the primary screening, a full-text screening was conducted with the resulting set of studies using the inclusion criteria, focusing specifically their usefulness in developing ICMOs on household gardening.

3. Extraction of data

The documents from Step 2 were tagged according to their coverage of the identified impact pathways for which relevant ICMO statements were abstracted. The studies were then subjected to a series of notetaking, annotation, and conceptualisation. The basic details such as author(s), date of publication, country of study, methodology, and key findings of the screened documents are reported within this article (See Additional file 3).

A data extraction table (See Additional file 4) was used to organise the information and findings relevant to developing programme theories. This four-column table includes (1) document code, author and country of study; (2) the intervention; (3) the mechanism, which outlines the contextual factors that trigger it and the cognitive response or reasoning of the individual to the intervention; and (4) corresponding outcomes.

The completed information was then synthesised into a list of initial programme theories, written as intervention-context-mechanism-outcome (ICMO) statements, with the corresponding studies providing supportive evidence for the statement.

4. Validation and refinement of programme theories

The initial list of programme theories was subjected to a series of crosschecking steps with the non-academic literature on food systems, household gardening, and other related fields, and validated via key informant interviews (KIIs) in a panel of three experts who hold relevant field experience in implementing household gardening programs. Verbal informed consent was obtained prior to each interview. Expert panel input is a key step in RRR to distil those insights that resonate with their experiences on actual household gardening program implementation. The expert panel also reflected on the actionability of the insights in the development of recommendations for policy and program implementation. The result of Step 4 is the final list of refined programme theories.

5. Synthesis of results

The findings were synthesised to identify recurrent outcome patterns, their associated intervention components, mechanisms, and contextual factors. The resulting theories were compared against existing literature from various fields to assess their applicability in the design of household gardening programs. Similarities and differences between the findings and the current evidence base provided insights into the utility of the theories and were used to generate actionable recommendations for future research and practice.

Results

Study characteristics

A total of 24 documents [30–53] were selected from the Vegetables Scoping Study database of Harris et al. [29] and analysed to develop programme theories on household gardening interventions. Figure 2 shows the resulting document flow following the screening steps performed in this review. Studies identified from the database search ($n=25$) were excluded due to reasons of being written in a language other than English, information provided did not cover household-level gardening interventions, or lacked information to develop programme theories. The summary of study characteristics can be viewed in Additional file 3.

All included studies ($n=24$) were published between 2002 and 2020 and conducted in LMICs. The specific geographical distribution of the studies indicates that most were undertaken in South Asia ($n=13$) and Sub-Saharan Africa ($n=8$). There were limited studies covering East Asia and the Pacific (n=3). No studies were included from Central Asia, Latin America and the Caribbean, and the Middle East and Northern Africa (MENA) regions. In terms of study design, all 24 studies involved the collection of primary data. Most of the studies were quantitative ($n=18$) and involved forms of measurement in dietary outcomes (e.g. dietary diversity, actual vegetable consumption) while 5 were mixed-methods studies.

The ICMO statements related to the production pathway were distilled from 19 studies, followed by the knowledge pathway in 17 studies, and the income pathway in 6 studies making it the least covered pathway. Some studies provided information in two or all three pathways, with production and knowledge as the most common pathway combination. Table 1 shows a summary of this categorisation across the pathways.

Using a data extraction table (See Additional file 4), programme theories relevant to the subject of household gardening were developed, distilled from the relevant studies. Each programme theory was written in an intervention-context-mechanism-outcome (ICMO) format and was checked for relevance in explaining the impact

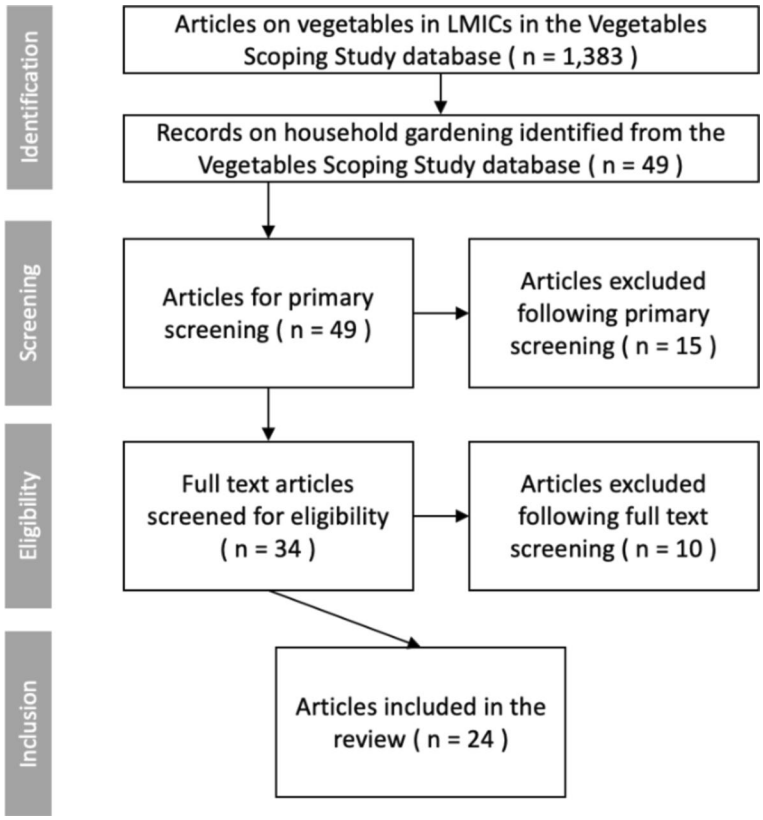

Fig. 2 Document flow diagram

Table 1 Number of studies relating to each impact pathway (Total $n = 24$)

Pathways	Number of studies	Percentage (%)
Production only	5	21
Income only	0	0
Knowledge only	4	17
Production and income	2	8
Production and knowledge	9	38
Income and knowledge	1	4
All three pathways	3	13
Total	24	100

pathways and underlying assumptions of household gardening as described in the initial conceptual framework (See Additional file 1). The key informant interviews with expert panel members provided valuable field insights into household gardening programme implementation which confirmed the relevance of certain programme theories and pointed out the limitations of other theories in guiding household gardening programme design, allowing a prioritisation of certain ICMO configurations.

Programme theories on household gardening along the impact pathways

The study hypothesised that the change in vegetable consumption from household gardening interventions transpires through three major pathways of production, income, and knowledge. A total of 11 ICMO statements which outline the mechanisms and their corresponding enabling and constraining contextual factors across the three pathways were produced from the review and validation process. Shown in Fig. 3 are the ICMO statements (from Tables 2, 3 and 4) mapped as black circles pointing to specific causal steps in the conceptual framework on household gardening.

Production pathway

Table 2 lists the programme theories under the production pathway and the corresponding supporting studies written as ICMO statements.

For the production pathway, the reviewed studies demonstrate that the path from the provision of agricultural inputs to changes in consumption can be elaborated by production-related ICMOs which pertain to the households' response and utilisation of resources obtained

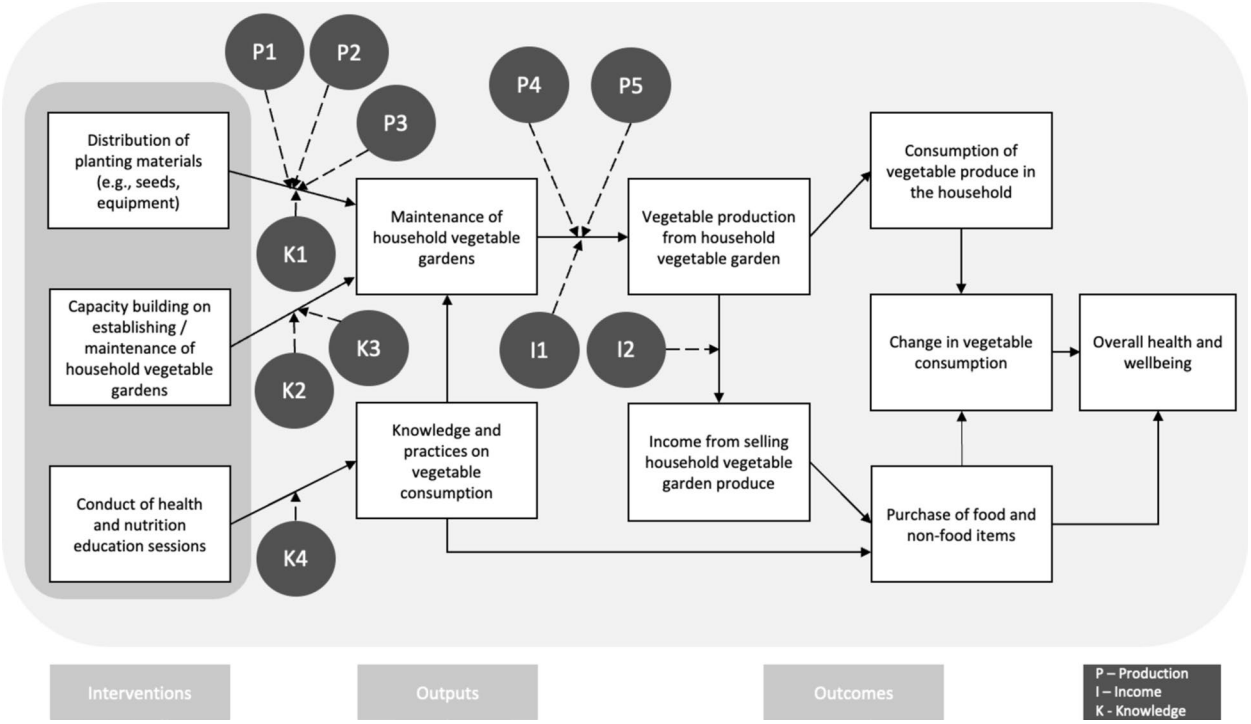

Fig. 3 Mapping of programme theories on the initial conceptual model on household gardening

Table 2 Programme theories under the production pathway

#	Programme theory as ICMO statements	Supporting studies
P1	If households are provided with agricultural inputs such as seeds, planting materials and other supportive infrastructure (e.g. irrigation facilities) to maintain gardens (I) amidst highly variable weather conditions and recurring planting seasons (C), then the incentive to become food secure year-round (M) encourages some households to adopt improved garden management practices [perhaps to increase vegetable yield] (O)	[30, 33, 37–41, 43, 52, 53]
P2	If the seeds, varieties, and technology provided to households (I) are new or rare to the area (C), then openness to experiment and increased interest (curiosity) for benefits in terms of yield and nutrition (M) motivates some households to actively maintain their vegetable garden (O)	[33, 42, 43, 45, 52, 53]
P3	If a household is provided with inputs and attempts to maintain a garden (I) where they have limited physical space and time for gardening along with other competing responsibilities (e.g. formal employment) (C), then feelings of frustration or being overwhelmed with the additional workload (M) can result in reduced effort invested in maintaining the garden [and perhaps decreased vegetable yield] (O)	[35–37, 41, 47, 53]
P4	If vegetable gardening is promoted at community level (I), and households who practice vegetable gardening have neighbours also doing the same activity (C), then opportunities for resource-sharing, knowledge exchange, and sense of community are increased (M) motivating some households to actively maintain their gardens [and perhaps share garden produce with neighbours] (O)	[34, 41]
P5	If households start household gardens (I) in a period when their gardens are continually affected by pest and livestock destruction and extreme weather events (e.g. flooding) (C), then lower self-confidence in their ability to manage the garden (M) can lead to reduced effort or neglect [and perhaps decreased consumption of produce from the garden] (O)	[33, 37, 43, 53]

from: (1) provision of materials such as seeds and seedlings, other equipment, and supportive infrastructure (e.g. irrigation), and (2) actual maintenance of vegetable gardens.

In the provision of gardening inputs, actual maintenance of household gardens and adoption of improved gardening practices were observed to be highly motivated by the incentive for households to be food secure year-round (P1). This was observed in ten studies and was triggered by contexts of highly variable weather conditions during dry and wet seasons, unseasonal rainfall, and the fluctuating household food supply especially during

Table 3 Programme theories under the income pathway

#	Programme theory as ICMO statements	Supporting studies
I1	If households who maintain gardens (I) are situated far away from markets that sell fresh produce (C), then increased sense of self-efficacy (M) can motivate better management of gardens [and encourage consumption of produce from vegetable gardens] (O)	[44, 46]
I2	If households maintaining vegetable gardens (I) have good market access for selling surplus produce or have limited garden sizes and are low-income (C), then the opportunity to resolve various household expenses (economic priorities) (M) motivates some households to sell produce [to purchase various non-food and food items] (O)	[37, 41, 44, 48, 52, 53]

planting seasons [30, 33, 37–41, 43, 52, 53]. Another mechanism that enabled the maintenance of gardens was the increased interest and experimental nature of households in achieving better yields (P2). Six studies cited the introduction of new vegetable varieties or novel gardening technologies as an associated context in eliciting such motivation for households to maintain their gardens [33, 42, 43, 45, 52, 53]. For example, in a kitchen garden project in Maharashtra, India, the seeds distributed were new to the area, mostly indigenous, and were reported to require minimal maintenance and withstand harsh climate conditions, which resulted in higher interest among intervention households. In addition to individual motivations, social connectedness and the increased opportunities for resource-sharing and knowledge-sharing motivated household to maintain gardens and share their produce (P3). This was especially observed in two studies where neighbouring households were engaged in the household gardening program and subsequently produced positive outcomes in terms of garden maintenance and sharing of produce [34, 41].

Conversely, mechanisms that led to reduced effort in garden maintenance and subsequently reduced yields were reportedly due to households being overwhelmed with the additional workload required from gardening (P3) or having lower self-confidence in maintaining the gardens (P5). Having insufficient physical space for gardening and limited time due to other competing responsibilities such as formal employment were the contextual factors found to trigger such mechanism [35–37, 41, 47, 53]. Similarly, the recurrent experiences of failure due to pest and livestock destruction, as well as extreme weather events such as flooding yielded negative effects on the confidence of households in maintaining their gardens [33, 37, 43, 53].

Income pathway

Table 3 lists down the programme theories under the income pathway and the corresponding supporting studies.

The programme theories developed along the income pathway demonstrated the use of household gardening as a supplemental source of income for households in LMICs in certain settings. The ICMO statements mostly pertained to (1) attributes of the gardening household and (2) external conditions of the household which influenced the decision to sell the produce and use the income derived from household garden for various purposes. The findings provided nuances to the conventional assumption that introducing income objectives to gardening would lead to better management of gardens and improved vegetable consumption.

Two studies [44, 46] pointed to self-efficacy triggered by household constraints in terms of increased distance from markets and high transportation costs which motivated households to better manage their gardens (I1). For example, a study on an integrated household gardening project in Nepal reported that caregivers take value in the

Table 4 Programme theories under the knowledge pathway

#	Programme theory as ICMO statements	Supporting studies
K1	If a household provided with agricultural inputs (I) has prior experience working in agriculture or vegetable gardening (C), then higher levels of self-confidence (M) can enable better management of gardens (O)	[32, 37, 39, 42]
K2	If the provision of capacity building on establishing and maintaining vegetable gardens (I) adopts community-based approaches such as organising, demo gardens, feedback sessions, and mobilisation of community facilitators (C), then the increased opportunities for resource-sharing, knowledge exchange, and enhanced sense of community (M) can enable better knowledge of gardening skills (O)	[31, 32, 38, 39, 41–45, 47, 48, 50]
K3	If the capacity building on establishing and maintaining household gardens and nutrition education (I) is directed to women, especially those with higher literacy rates and educational level (C), then the increased sense of responsibility in household meal preparation coupled with higher self-confidence (M) can enable the sustained management of vegetable gardens (O)	[30, 32]
K4	If households maintaining vegetable gardens (I), participate in nutrition education sessions that introduce the benefits of vegetable consumption (C), then the increased sense of responsibility for the health of household members (M) can result in the consumption of produce from the vegetable garden (O)	[33, 36, 37, 44–46, 48]

lesser time spent traveling to the market since vegetables were readily available in their households [44].

As observed from a few studies, households sold and derived income from household gardening largely due to economic priorities such as the opportunity to resolve various household expenses (I2). Such mechanism is triggered by the presence of good market access, and having limited garden size and being categorised as low-income where more low-income households were found to practise the selling produce [37, 41, 48]. Further, three studies cited surplus production and a reliable market to be preconditions that triggered economic priorities and motivated households to sell produce in the markets for supplemental income [44, 52, 53].

Knowledge pathway

Table 4 lists down the programme theories under the knowledge pathway and the corresponding supporting studies.

The knowledge pathway involves interventions that aim to increase the knowledge of households in household gardening, health and nutrition practices, including the importance of vegetable consumption. The ICMO statements in this pathway pertained to interventions along: (1) provision of capacity building on establishing and maintaining household gardens and (2) conduct of health and nutrition education sessions for households. These interventions are intended to increase knowledge and interest and sustain the adoption of household gardening while promoting optimum nutrition practices such as vegetable consumption.

In the provision of agricultural inputs, a higher level of self-confidence was noted to be a mechanism triggered by prior experience in agriculture and vegetable gardening (K1). Four studies have identified this mechanism and enabling context which eventually led to the better management of gardens [32, 37, 39, 42]. In a study by Faber et al. [39] in a home garden project in South Africa, the project strengthened the already existing gardening activities of households by introducing vitamin-A rich crops such as dark-green leafy vegetables which ultimately led to greater improvements in consumption and micronutrient status of children in the gardening community.

Capacity-building sessions on household vegetable production were commonly incorporated as a component of household gardening programs. Twelve studies found that the increased opportunities for resource-sharing, knowledge exchange, and enhanced sense of community greatly sustained the management of vegetable gardens (K2). Such mechanism and outcome were triggered by the adoption of community-based approaches in program implementation such as community sessions, setting up and use of demonstration gardens, establishing of feedback mechanisms, and the mobilisation of community facilitators whom gardening households constantly counted on for technical support [31, 32, 38, 39, 41–45, 47, 48, 50].

Aside from the technical support, two of the reviewed studies also found that the increased sense of responsibility in household meal preparation coupled with higher self-confidence and control over gardening resources enabled the sustained management of the household garden (K3). The involvement of women in input provision and capacity building was an important enabling condition that yielded positive results in terms of adoption and knowledge on the importance of vegetable consumption [10, 30, 32].

In seven reviewed studies, household gardening was complemented with forms of nutrition education for gardening households. It was observed that this enabled an increased sense of responsibility for the health of household members which was a mechanism that determined whether a household would sustain and consume the vegetables from the garden (K4). In this case, participation in nutrition education sessions was an important enabling contextual factor while the absence/non-participation in nutrition education led to converse effect on the knowledge and adoption of desirable practices from household gardening [33, 36, 37, 44–46, 48]. Three studies reported that the lack of knowledge on the benefits of vegetable consumption resulted in limited consumption of vegetables despite the presence of a vegetable garden resource [33, 36, 48].

Discussion

Household gardening is a complex intervention often implemented with multi-component activities that produce various effects intended to enable positive outcomes in diets, incomes, and knowledge, to achieve optimum nutrition. This rapid realist review of 24 primary studies affirms the relevance of the three pathways of production, income, and knowledge described in the initial conceptual framework. Beyond this, the study situates the programme theories to elaborate in more depth how household gardening can contribute to improving vegetable consumption in LMICs.

While this review is not intended to be exhaustive of all possible ICMOs, the study reveals several recurring themes and important insights that policymakers and program planners in LMICs can use in improving the design of these interventions. The major findings in relation to existing literature and their implications for food security and nutrition programming are discussed according to the pathways and are also linked to the insights about household gardening published in this

journal. The reviewed studies mentioned in this section are referred to by their bibliographical reference number.

Production pathway

The production pathway is the most dominant pathway analysed in the field of nutrition-sensitive agriculture programming given its direct potential in increasing household availability of vegetables for own consumption and improving nutrition [54]. The initial impact pathway assumes a straight progression from garden maintenance to production and consumption. However, the review revealed several enabling and constraining mechanisms and associated contextual factors within the pathway.

One of the enabling mechanisms mostly observed was the opportunity provided by the vegetable garden to be more food secure year-round. In resource-poor households in Cuba, gardening provided a protective effect against recurring food shortages where gardens provided a convenient and accessible source of food for the household [55]. However, this effect is challenged when measures are not taken to increase resilience of gardens to external threats such as highly variable weather conditions.

Seasonality is a contextual factor that triggered lower self-confidence and reduced the intention to garden in many of the reviewed studies. In a study by Hendriks et al. [56] on food production programmes in rural South Africa which included household gardening, seasonality affected the availability of vegetables for household consumption. The growing unpredictability of weather systems has been seen to reduce motivation and consequently the overall benefits of household gardening, except for households with access to water and appropriate technology, who were still able to produce year-round [57]. This emphasises the need for interventions to factor adaptive strategies such as the introduction of perennial crops, locally available indigenous seeds and seedlings that are more climate resilient [58], staggered planting techniques, supportive infrastructure, and cost-effective and easy-to-use technology to acquire water [56, 59]. These considerations have grown more critical in the context of gardening and overall sustainability, with households expected to have more difficulty securing adequate production and nutritionally adequate diets in the context of climate and environmental change [60].

Other contextual factors that triggered lower self-confidence in gardening were the limitations in gardening space faced by households. In a study by Du Toit et al. [61] on household gardens in South Africa, perceived insufficient space hindered the decision to establish gardens. This challenges the applicability of household gardening in conditions of agricultural inequality and landlessness which are ethical issues that need to be accounted in engaging households to similar programmes [62]. Although in some studies, limitations in gardening space have been managed by adopting vertical or rooftop farming, and other applicable space-saving gardening technologies [63].

Moreover, it has been found that some households with available space cited poor soil quality and recurrent experiences of pest infestation which constrained the management or expansion of vegetable gardens. In such case, the application of a range of sustainable horticultural practices, such as the use of organic fertilisers, provide benefits to soil health, nutrient cycling, environmental health, and overall yields [64]. Further, strategies such as integrated pest management (IPM), which involves a coordinated process of using a combination of sustainable, ecological, and economical pest management practices, have a potential to address the unique concerns and contexts of gardening households [65]. IPM as applied to vegetable farming has been found to result in effective pest mitigation and greater crop productivity, especially when a combination of control methods are applied such as intercropping compatible crops and the use of aqueous plant extracts as pesticides, as well as other mechanical and biological methods, as demonstrated by a study of vegetable farmers in Nigeria [66] and the use of indigenous plants as a source of pesticide and organic fertiliser for home gardens in the Terai plain in Nepal [67]. These methods have been widely observed to manage pests in a safer and more sustainable way, as opposed to pesticides made from synthetic chemicals which have several health and environmental risks [68]. With these, gardening programs need to account both the availability and quality of the land available to households, and couple these with accessible and appropriate capacity-building, to better manage recurring issues in gardening and ensure adequate vegetable production.

In terms of time and self-confidence, participation in gardening been observed to increase time-burden for households. This constraint has also been observed in gardening projects in Cambodia [57] and in an urban gardening initiative in Benin, where time and labour concerns discouraged own food production and more preference is often given to buying food for its convenience [69]. Urban areas present more challenging conditions given the combined constraints of space, time, and labour which urge the need to assess the availability of such resources when introducing gardening to ensure success.

Another enabling mechanism in this pathway was the openness to experiment and increased interest triggered by the introduction of new seeds, varieties, and technologies. More often, households already producing vegetables are found to display higher enthusiasm to partake in

such projects [70]. A case study in an indigenous community in Cameroon revealed that the use and promotion of indigenous or traditional vegetables in the project elicited higher desirability from the households and eventually became the most consumed in the households [71]. Although in some cases, indigenous vegetables can have lower acceptability due to cultural values such as the preference for meats and associations with poverty and lack of awareness of nutritional benefits [72]. With this, program planners could benefit from considering local acceptability and building on existing motivation and preferences when leveraging experimentation and curiosity in household gardening programs, to maximise their benefits in food security and nutrition.

While mentioned only in two of the reviewed studies, having neighbours practising vegetable gardening triggered a sense of community and heightened increased opportunities for resource sharing and knowledge exchange. This has led to the active maintenance of the practice which results from the social dimension of gardening [9]. Findings on the effect of neighbours' gardening on household dietary diversity in Tanzania also reveal a positive effect and intervention households were also seen to promote gardening or share produce with neighbours [73]. Studies from the field of environment and conservation find that the deep social nature of individuals channel people towards conformity and reciprocity which lead to adherence to desirable practices [74]. Further, cultural values around gardening for particular groups have been found to sustain gardening practice as it provides people a sense of belonging and connection with their cultural identity [75]. Ensuring that household gardening becomes an observable behaviour in the community and integrates with local culture can trigger peer influence and help turn gardening also into a social practice that motivate households to sustain.

Income pathway

The income pathway posits that income generated from vegetable gardening activities can enable vegetable-rich diets and improved nutrition through household food expenditures [15]. This review revealed that in several studies, the opportunity to resolve household expenses was a mechanism that led households to sell their garden produce. Among the observed contexts for such mechanism to occur is the proximity of households to markets and secured buyers for garden produce.

Proximity of gardening households to the markets can influence the decision to sell vegetables, where a study in Bangladesh saw that households with good access to markets earned two to three times higher income from vegetable production than those with limited access to markets and used vegetables solely for their consumption [76]. Interestingly, longer distances to markets have been observed by Akwango et al. [77] to positively affect food security of households as members worked more on their farms than spending leisure time (e.g. drinking) at the markets. A multi-country study on a garden intervention in Africa also found that households had stronger preference on selling their produce rather than own consumption and also noted that these households were already producing vegetables prior to the intervention [70]. Di Prima et al. [78] further contextualises these findings by stating that income objectives in related nutrition-sensitive agricultural interventions are harnessed more often in urban areas or with good access to markets and where there is adequate demand for food commodities.

While the income pathway has shown potential in improving diets and nutrition, decisions on whether the income gained from activities such as household gardening is used to purchase vegetables are dependent on a multitude of factors such as physical and economic access [79] and individual-based motives, including sociocultural beliefs and health and nutrition knowledge and perceptions [80]. The studies covering the income pathway revealed that in many cases, various food and non-food items are bought for overall wellbeing and not necessarily for nutrition.

The assumption that gardening production and income would translate into better nutrition practices is challenged by a long-term cross-sectional study by Marek et al. [81] in Senegal which saw that among low-income gardening households, only 1% of the money from vegetable sales was spent on food. The highest expenditures were on clothing, savings, and farm inputs such as seeds and fertilisers, explaining the marginal effect of income on improving diets. In the same study location, there was also a reported lack of awareness among mothers earning from their vegetable gardens on the value of vegetable consumption in ensuring child nutrition status [82]. The use of income for food and nutrition is even further contested in the context of fluctuating food prices which highly burden the poor [83].

Given these, the integration of income objectives in household gardening program designs would also need to consider the control of resources within the household. A study by Nabuuma et al. [84] with smallholder farmers in Uganda reveals that men prefer to sell most of the harvest and use the income to pay bills and school fees. Several studies point to the positive benefits of women's control over household income towards food consumption and child nutrition. In projects that involved women in Bangladesh and Nepal, women beneficiaries gained more involvement in household decision-making especially in keeping the income which was mostly used to buy food, with some portion used for savings and education [85].

These findings suggest looking further into mediators and actual nutrition outcomes resulting from such varied household arrangements and for gardening projects to actively integrate nutrition education to ensure that gardening income is used for purchasing nutritious food and the practice of other positive health and nutrition behaviours.

Knowledge pathway

The knowledge pathway outlines how interventions such as agricultural capacity building and nutrition education sessions render their effect on improving vegetable-rich diets and nutrition. The implementation of capacity building and health and nutrition education activities is a feature of many household gardening interventions in this review which trigger an increased sense of responsibility for the health of household members.

Knowledge promotion activities often operate under various mechanisms. In several studies, the involvement of women enabled positive outcomes in terms of garden maintenance and consumption via mechanisms of increased levels of self-confidence and increased sense of responsibility for meal preparation. This is consistent with various studies on the link of agriculture to nutrition which show that women's status, time, and resource control were found to be key mediators between agricultural inputs, resource allocation, and nutritional status [86]. These contributions were assessed in an econometric study in Ethiopia, where women's nutrition knowledge and measures of their empowerment were positively correlated with food group consumption and child nutrition, affirming the potential of improving women's knowledge in food security and nutrition interventions [87].

With the emphasis on women, however, there is a need to mitigate potential negative effects of using women's time on agricultural activities. In a study by Depenbusch et al. on a gardening project in Cambodia [57], gardening was found to increase time burden for households with women significantly contributing more time than men. However, mitigating actions are shown in studies on integrated agriculture programs in Malawi [88] and Sierra-Leone [89] which found that the joint involvement of men and women in participatory nutrition education and training sessions led to greater involvement in food preparation and child care among men, with the program also actively addressing gender pre-conceptions and norms.

Other recommendations also include the promoting the division of tasks with other household members on health and nutrition [90] where in some contexts, engaging younger household members in capacity-building on gardening present additional benefits to gardening sustainability and their individual wellbeing [91]. Ultimately, the results of these knowledge efforts need to be monitored as a study on an integrated home garden intervention in Bangladesh found that effects of capacity building on indicators such as planting of nutrient-dense leafy vegetables, per capita vegetable intake, seasonal production, were found to weaken after 6 years of the intervention, suggesting the need to include continuing education for households participating in similar interventions [92].

In addition, the adoption of community-based approaches was also found to be a commonly observed enabling context that triggered mechanisms of increased opportunities for resource-sharing, knowledge exchange, and community cohesion. The use of community-based approaches, where gardening households were organised in a support network and engaged throughout implementation, monitoring, evaluation, and learning, have also been adopted in a home gardening programme in Bangladesh [93] and a nutrition-sensitive agriculture program in Vietnam [94] where it has stimulated project success. Maximising the available information access channels, leaders, and networks in the community is recommended as a strategy that can support the broader dissemination of essential information on improving food security and nutrition in communities.

Conclusion

Household gardening has high potential for improving vegetable-rich diets in LMICs by increasing household access to vegetables (production pathway), providing a supplemental source of income for the purchase of essential goods (income pathway), and improving knowledge through the provision of health and nutrition education (knowledge pathway). These impact pathways were identified from the existing food systems literature and were found to be applicable as a conceptual framework in reviewing and broadening the evidence on household gardening interventions in LMICs.

The application of the realist review methodology was useful in uncovering various mechanisms and contextual factors along each impact pathway that need deeper consideration in the design of household gardening programs intended to improve vegetable consumption. Food security and nutrition programmes can utilise the results to tailor interventions better to these multiple micro-contexts and trigger the mechanisms that motivate households to start and maintain household gardening. Leveraging these mechanisms offer more likelihood of benefits for both participating households. Further, an early identification and consideration of personal, household, social and environmental contexts is crucial, as these may also impact the motivation and ability to practice and sustain household gardening.

A limitation of this study is the lack of empirical material to further elaborate factors such as equitable resource allocation, culture, and gender, which are known factors for improving diets and nutrition [95]. The study is also limited in explaining how broader political and economic contextual factors at the national, regional, and global levels affect the capacity and decision to pursue household vegetable production. As a recommended immediate step, this study can benefit from an expanded or complementary search to account for further studies and beyond the indicated timeline of the review.

Future research on household gardening interventions may build on these findings to probe specific impact pathways and programme theories, to establish the case for implementing context-specific nutrition-sensitive programmes that link agriculture, economic, education, and nutrition, and fully maximise the contribution of household gardening in advancing the global sustainable development agenda [5]. As more empirical evidence on food systems and household gardening emerges, it is essential to update current understanding and program configurations to achieve the desired outcomes on vegetable consumption and ultimately improve health and nutrition.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40066-025-00523-6.

Additional file 1. Conceptual framework for realist synthesis. This file provides the conceptual framework used as the starting point for the realist synthesis on household vegetable gardening interventions in LMICs.

Additional file 2. Report items in realist synthesis and corresponding sections. This file provides a summary of the report items of the RAMESES guidelines for realist synthesis and where each report item can be found in the study.

Additional file 3. Summary of characteristics of reviewed studies. This file provides a summary of the basic details such as author(s), date of publication, country of study, methodology, and key findings of the screened documents for the review.

Additional file 4. Completed data extraction table. This file provides a summary of the information and findings relevant to developing programme theories and includes the following: 1) document code, author and country of study, 2) the intervention, 3) the mechanism which outlines the contextual factors and the cognitive response or reasoning of the individual to the intervention, and 4) the corresponding outcomes.

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Author contributions
AF led the conceptualisation of the study design, data collection and management, writing of initial drafts, and the development of the final manuscript to its submission. JH and GT provided technical guidance in the study design, data analysis, contextualisation of results and discussion, preparation, proofreading, and editing of the final manuscript to its submission.

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Availability of data and materials
All data generated and analysed for this study are duly available as part of the supplementary information files of this published article.

Declarations

Ethics approval and consent to participate
The respondents who were interviewed in this study willingly provided their explicit consent through a verbal agreement. Further, they were informed that they can freely opt to terminate their participation at any point of the interview.

Consent for publication
All the authors consent to the submission and publication of this study.

Competing interests
The authors declare that they have no competing interests in the conduct and publication of this study.

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