UNIVERSIDADE PAULISTA - UNIP

PROGRAMA DE PÓS-GRADUAÇÃO EM ENGENHARIA DE PRODUÇÃO

CADEIA DE SUPRIMENTOS DO PROGRAMA NACIONAL DE ALIMENTAÇÃO ESCOLAR NA CIDADE DE MOGI DAS CRUZES/SP

Tese apresentada ao Programa de Pós-Graduação em Engenharia de Produção da Universidade Paulista - UNIP, para obtenção do título de Doutor em Engenharia de Produção

JOÃO ROBERTO MAIELLARO

SÃO PAULO

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Orientador: Dr. João Gilberto Mendes dos Reis

Área de Concentração: Gestão de Sistemas de Operação

Linha de Pesquisa: Métodos Quantitativos em Engenharia de Produção

Projeto de Pesquisa: Aplicação de Ferramentas e Métodos Quantitativos na solução de problemas em Engenharia de Produção e Logística

JOÃO ROBERTO MAIELLARO

SÃO PAULO

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JOÃO ROBERTO MAIELLARO

CADEIA DE SUPRIMENTOS DO PROGRAMA NACIONAL DE ALIMENTAÇÃO ESCOLAR NA CIDADE DE MOGI DAS CRUZES/SP

Tese apresentada ao Programa de Pós-Graduação *Strictu Sensu* em Engenharia de Produção da Universidade Paulista - UNIP, como pré-requisito para obtenção do título de Doutor em Engenharia de Produção.

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DEDICATÓRIA

À Valéria, ao Lucas e à Manu

Aos meus pais Mário Maiellaro *(in memorian)* e Maria Maiellaro

E dedico esta pesquisa a todas as crianças que passam fome no mundo...

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"Encontrou-se, em boa política, o segredo de fazer morrer de fome aqueles que, cultivando a terra, fazem viver os outros"

Voltaire

RESUMO

Programas de alimentação escolar são ações governamentais presentes em vários países. No Brasil, umas das principais ações do Fundo Nacional de Desenvolvimento da Educação (FNDE) é o Programa Nacional de Alimentação Escolar (PNAE), reconhecido como um dos mais importantes programas de alimentação escolar do mundo. No mínimo, 30% dos recursos do programa devem ser investidos na compra de alimentos da agricultura familiar. A complexidade das operações logísticas nas cadeias de suprimentos da merenda escolar limitam a capacidade de crescimento e dificultam a manutenção dos esforços governamentais para promover a alimentação ideal para estudantes. Esta pesquisa buscou analisar a operação logística da cadeia de suprimentos da alimentação escolar na cidade de Mogi das Cruzes no âmbito do Programa Nacional de Alimentação Escolar (PNAE) e levantar alternativas de melhoria. Métodos quantitativos foram utilizados, como *Social Analysis Network* (SNA), *Analitic Hierarchy Process* (AHP) e Simulação de Eventos Discretos. Também foram adotados métodos de análises espaciais baseados em Sistemas de Informações Geográficas (GIS). A pesquisa demonstra que há dificuldade de entendimento do sistema logístico pelos atores que atuam na cadeia de suprimentos do PNAE com foco na agricultura familiar. Os resultados mostram que a visão dos diferentes atores da cadeia de suprimentos podem ser consolidadas em um sistema decisório multicritério e há oportunidades de melhoria operação logística.

Palavras-chave: alimentação escolar, logística, agricultura familiar

ABSTRACT

School feeding programmes are governmental actions present in many countries. In Brazil, one of the main efforts of the Fundo Nacional de Desenvolvimento da Educação (FNDE) is the Programa Nacional de Alimentação Escolar (PNAE), recognized as one of the most important school feeding programmes in the world. At least 30 % of the financial resources should be invested in the purchase of food from family farming. The complexity of logistics operations in the supply chains of school feeding constrains the growth and hinder the maintenance of governmental attempts to promote adequate feeding for students. This research investigated the logistics operation of the PNAE's Short Food Supply Chain in Mogi das Cruzes city to raise alternatives for improvement. Quantitative methods were used, such as Social Analysis Network (SNA), Analytic Hierarchy Process (AHP) and Discrete Events Simulation. Spatial analysis methods based on Geographic Information Systems (GIS) were also adopted. The research shows that there are difficulties in understanding the logistic system by the actors involved. The results show that the opinion of the different actors in the supply chain can be consolidated into a multi-criteria decision-making process and there are opportunities to improve the logistics operation

Keywords: School Feeding, logistics, family agriculture

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LISTA DE ABREVIATURAS E SIGLAS

APA *American Psychological Association*

AHP *Analytic Hierarchy Process*

CAPES Coordenação de Aperfeiçoamento de Pessoal de Nível Superior

DAE Departamento de Alimentação Escolar da cidade de Mogi das Cruzes

FAO *Food and Agricultural Organization of the United Nations*

FNDE Fundo Nacional de Desenvolvimento da Educação

FSC *Food Supply Chains*

GIS *Geographic Information System*

HGSF *Home Grown School Feeding*

HGSFHP *Home Grown School Feeding and Health Programme*

IDEB Índice de Desenvolvimento da Educação Básica

IDGM Índice dos Desafios da Gestão Municipal

INCRA Instituto Nacional de Colonização e Reforma Agrária

MEC Ministério da Educação

NEPAD *New Partnership for Africa's Development*

NHGSF *The Nigerian Home Grown School Feeding*

ODS Objetivos de Desenvolvimento Sustentável

PAA Programa de Aquisição de Alimentos

PNAE Programa Nacional de Alimentação Escolar

PPGEP Programa de Pós-Graduação em Engenharia de Produção

SFSC *Short Food Supply Chains*

SNA *Social Analysis Network*

TI Tecnologia da Informação

WFP *World Food Programme*

SUMÁRIO

1 Introdução

Autores reconhecem a importância de estudos que abordam as cadeias de suprimentos de alimentos, referenciadas na literatura como *Food Supply Chains* (FSC) e do papel desempenhado pelos programas de alimentação escolar (Sonnino et al., 2014; Chauhan, 2015; Soares et al., 2017; Torres & Benn, 2017), como um caminho para se garantir a segurança alimentar durante a infância e juventude (Kummu et al., 2012; Lebersorger & Schneider, 2014; Bilska et al., 2016; Kristjansson et al., 2016; Belik & Fornazier, 2017; López-Olmedo et al., 2018).

Um dos obstáculos à segurança alimentar para a totalidade dos seres humanos é a quantidade de alimentos produzida não consumida. Estima-se que um terço de todo alimento produzido para consumo humano é perdido ou desperdiçado. Em 2050, a produção de alimentos deverá ser 60% maior se comparada a 2005 (FAO, 2013). Perdas de alimentos, ocorrem nas diversas etapas da cadeia de suprimentos (Garrone et al., 2014; Bilska et al., 2016; Cicatiello et al., 2016).

Déficits nutricionais em idade escolar trazem forte impacto no comportamento e no desenvolvimento intelectual. Estudos sobre a alimentação de crianças em fase escolar têm sido conduzidos (Azeredo et al., 2015; Cabrera-Vique et al., 2015; Condon et al., 2009)

A relação entre alimentação adequada na infância e os programas de alimentação escolar é direta. A maioria dos países demonstram esforços em alimentação escolar. Baseando-se em pesquisa realizada em 169 países, estima-se que 368 milhões de crianças são alimentadas diariamente nas escolas e o potencial investimento anual está entre 47 e 75 bilhões de dólares, e a maior parte desse investimento é previsto em orçamentos governamentais (WFP, 2013).

A experiência brasileira com programas de alimentação escolar tem sido referência nos anos recentes como umas das mais efetivas do mundo, estimulada pela lei 11947 (Lopes & Diniz, 2018). A lei 11947 prevê que no mínimo, 30% dos recursos do Programa Nacional de Alimentação Escolar (PNAE) sejam destinados para a compra de alimentos da agricultura familiar (Brasil, 2009).

Em 2017, o PNAE atendeu 41 milhões de estudantes da educação básica com investimento de R$ 3,90 bilhões, com incremento de 10,8% em relação a 2016 (FNDE, 2018).

Em 2015, o número de municípios atendidos pelo PNAE foi 5262 (FNDE, 2017b) do total de 5570 municípios brasileiros (IBGE, 2019). A abrangência do PNAE, portanto é de aproximadamente 95% do total de cidades no Brasil. Os valores repassado pela União a estados e municípios por dia letivo por aluno são R$ 1,07 para creches,

R$ 0,53 para pré-escolas, R$ 0,64 para escolas indígenas e quilombolas, R$ 0,36 para ensino fundamental e médio, R$ 0,32 para educação de jovens e adultos, R$ 1,07 para ensino integral, R$ 2,00 para o Programa de Fomento às Escolas de ensino médio em tempo integral e R$ 0,53 para alunos que frequentam atendimento educacional especializado (FNDE, 2017b).

Short Food Supply Chains (SFSCs) são cadeias de suprimentos que conectam produtores locais de alimentos e consumidores, reconfigurando essa relação em termos de tempo de fornecimento e distâncias menores (Paciarotti & Torregiani, 2018).

Conectar a agricultura familiar local aos programas de alimentação escolar pode ser um dos pontos críticos de sustentabilidade desses programas. Países como Brasil, Chile e Escócia, têm demonstrado sucesso em destinar recursos dos programas de alimentação escolar para compra de alimentos da agricultura familiar. Porém, é comum que programas de alimentação escolar necessitem de melhorias de infraestrutura e da operação logística para assegurar sua eficiência (WFP, 2013).

Atividades como embalagem, armazenagem, gerenciamento de estoques e transporte podem ser desafiadoras em cadeias de suprimentos de alimentos. É comum haver pressão para que as tarefas pós-colheita sejam realizadas no menor tempo possível. Demora no transporte de produtos perecíveis podem causar perdas significativas (Behzadi et al., 2018).

Mogi das Cruzes é umas das principais cidades do cinturão verde de São Paulo, com grande importância na produção de alimentos, como verduras, frutas, legumes (Santos & Bello, 2014). Recursos do PNAE são utilizados para aquisição de alimentos destinados à merenda escolar. A rede é formada por 58 agricultores familiares locais e 209 escolas públicas municipais. Os 13 itens comprados são: abobrinha, chuchu, salsa, repolho, couve-manteiga, beterraba, cebolinha, agrião, alface, cenoura, couve-flor, escarola e acelga. A aquisição dos gêneros alimentícios, no âmbito do PNAE, deve obedecer a cardápio elaborado por nutricionista responsável e ser realizada, sempre que possível, no mesmo ente federativo em que se localizam as escolas (Brasil, 2009).

A secretaria da agricultura homologa os agricultores familiares como fornecedores ativos do programa. As compras são efetuadas pelo Departamento de Alimentação Escolar (DAE), que é subordinado à secretaria da educação. A aquisição pode ser realizada dispensando-se o procedimento licitatório, mediante prévia chamada pública, desde que os preços sejam compatíveis com os vigentes no mercado local (Brasil, 2009).

Considera-se chamada pública, o procedimento administrativo voltado à seleção de proposta específica para aquisição de gêneros alimentícios provenientes da Agricultura Familiar ou Empreendedores Familiares Rurais e suas organizações. As entidades executoras publicam editais de chamada pública para aquisição de gêneros

alimentícios para a alimentação escolar e divulgam para organizações locais da agricultura familiar e para entidades de assistência técnica e extensão rural do município ou do estado. Os agricultores aderem por meio de apresentação de elaboração do Projeto de Venda de Gêneros Alimentícios da Agricultura Familiar para a Alimentação Escolar (FNDE, 2019a).

A intermediação entre os agricultores familiares e a prefeitura é feita por cooperativas de produtores da região de assentamento das propriedades rurais. Os alimentos são entregues na sede da Associação dos Produtores Rurais de Jundiapeda e Região (APROJUR), local em que as cooperativas realizam operação de *cross-docking*. Uma empresa transportadora é contratada pelas cooperativas para realizar a distribuição dos alimentos nas escolas. Cooperativas enfrentam desafios de governança, particulamente em países em desenvolvimento devido à limitada habilidade gerencial e falta de recursos financeiros (Royer et al., 2017).

O Departamento de Alimentação Escolar (DAE) está localizado em área urbana e próximo a uma região com grande concentração de escolas. As instalações do DAE são cogitadas como um possível novo ponto de *cross-docking* por produtores e por membros da secretaria da agricultura.

Relatos de envolvidos na cadeia de suprimentos levantam percepções de que a operação logística poderia ser melhorada. Também há percepção de que o programa de alimentação escolar poderia ser alavancado em termos de escala, porque a produção de alimentos é relevante no município. Novos produtores poderiam ser incluídos e itens poderiam ser fornecidos. Dentre as barreiras estão as dificuldades em se obter a Declaração de Aptidão ao Pronaf (DAP) e a desmotivação dos agricultores familiares com o PNAE. Os custos logísticos contribuem com a não-adesão de novos agricultores.

O setor de agronegócio é competitivo e dinâmico, com incertezas relacionadas a diversas questões, inclusive logísticas. Modelos de apoio decisório desempenham papel importante para auxiliar gestores ao longo dessas cadeias de suprimentos mutáveis e complexas (Soto-Silva et al., 2016).

Embora o interesse dos gestores públicos em fomentar a produção local de alimentos tenha crescido em muitas partes do mundo, há poucos estudos quantitativos que possam avaliar a viabilidade das políticas de promoção da agricultura familiar local (Khan et al., 2019). Os desafios logísticos são, muitas vezes, um dos maiores entraves à sustentabilidade econômica das cadeias de suprimento de alimentos locais (Mittal et al., 2018).

As melhores práticas logísticas das cadeias de suprimentos convencionais têm o potencial de melhorar a eficiência e a eficácia das *short food supply chains* (Mittal et al., 2018).

Em engenharia de produção, a gestão de suprimentos e da distribuição física

considera um conjunto de atividades relacionadas e limitadas por vários fatores, em múltiplos elos de uma cadeia. Modelos permitem identificar problemas, formular estratégias e oportunidades, apoiar e sistematizar o processo de tomada de decisões. Modelos quantitativos são descritos em linguagem matemática e computacional e seu cerne está nos métodos da pesquisa operacional, desde seu advento na Inglaterra e nos Estados Unidos (MIGUEL et al., 2012).

A literatura tem demonstrado modelos conceituais e análises das FSCs (Betz et al., 2015; Kummu et al., 2012; Willersinn et al., 2015) em que técnicas quantitativas são aplicadas no intuito de se obter melhorias operacionais e logísticas (Soto-Silva et al., 2016; Etemadnia et al., 2015). A aplicação de métodos quantitativos baseados em pesquisa operacional tem trazido impacto impressionante e contribuição significativa (Hillier & Lieberman, 2013).

Dentre os métodos da pesquisa operacional aplicados na engenharia (figura 1) estão a programação em redes métodos de simulação e *Analytic Hierarchy Process* (Belfiore & Fávero, 2013).

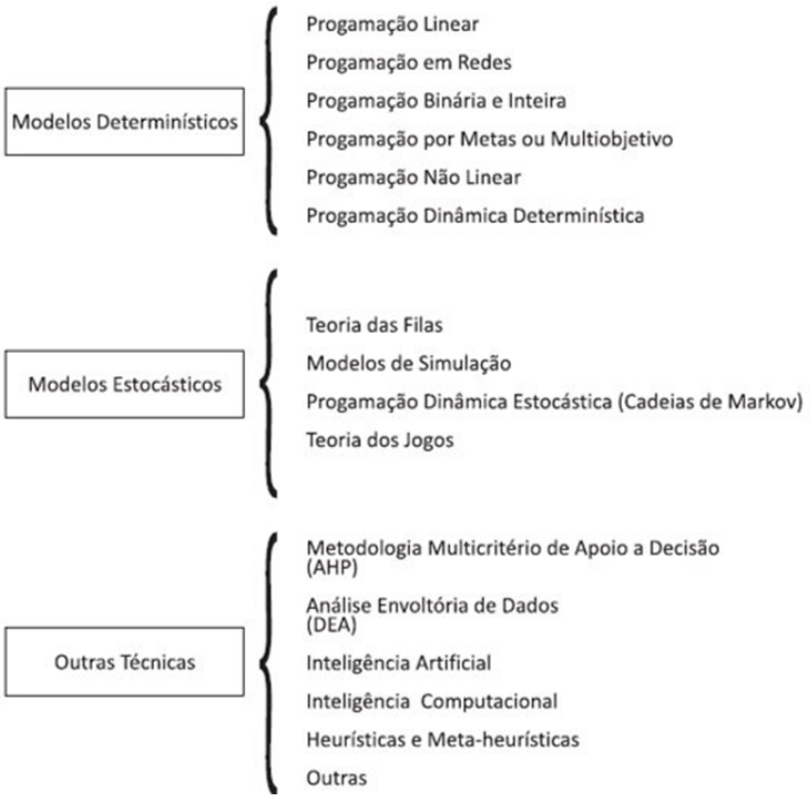


Figura 1: Métodos da Pesquisa Operacional (Belfiore & Fávero, 2013)

O contexto dos cenários apontados representam oportunidades de pesquisa das operações logísticas do Programa Nacional de Alimentação Escolar na cidade de Mogi das Cruzes, com amplas possibilidades de aplicação de métodos lógico-quantitativos.

1.1 Questões da pesquisa

Em face da impressão inicial de que existem oportunidades de melhorias na cadeia de suprimentos que envolve a agricultura familiar, escolas públicas e o governo municipal de Mogi das Cruzes, e com base nos aspectos amplos da pesquisa, questões podem ser levantadas:

- Todos os 13 tipos de alimentos são consumidos em toda a rede de 209 escolas?
- Há grupos de escolas que consomes alimentos distintos?
- O aumento da escala do PNAE em Mogi das Cruzes poderia ser obtido por meio de padronização do consumo e do perfil de demanda das escolas?
- Os itens de maior volume causam impacto na operação de transporte?
- É possível levantar os múltiplos critérios que impactam na cadeia de suprimentos e avaliar alternativas de melhoria logística com base na visão integrada dos diversos atores envolvidos?
- Quais são os fatores de maior impacto na cadeia da merenda escolar, definidos com base no julgamento dos principais atores envolvidos nas operações de produção, compras e distribuição?
- Um novo ponto de *cross-docking* pode trazer melhorias para a distribuição dos alimentos adquiridos da agricultura familiar?

1.2 Objetivos da pesquisa

Esse estudo tem como objetivo analisar a operação logística da cadeia de suprimentos da alimentação escolar na cidade de Mogi das Cruzes, considerando os produtores rurais locais e a rede de escolas públicas do município, no âmbito do Programa Nacional de Alimentação Escolar (PNAE). A pesquisa busca identificar oportunidades de melhorias logísticas com base na visão contextualizada dos agricultores familiares, das cooperativas de produtores, das escolas, da secretaria da educação, da secretaria da agricultura e do operador logístico responsável pela distribuição.

1.2.1 Objetivos específicos

Esta tese objetiva:

1. Mapear a cadeia de suprimentos agroalimentar *(Short Food Supply Chain)* que envolve a operação logística do Programa Nacional de Alimentação Escolar na

cidade de Mogi das Cruzes, para maior entendimento e aprofundamento nas análises.

2. Avaliar o fluxo de alimentos a partir dos produtores locais até as escolas.

3. Levantar a visão dos diversos atores da cadeia de suprimentos e avaliar fatores de maior impacto e alternativas de melhoria logística.

4. Analisar e propor melhorias na operação de distribuição de alimentos na cadeia de suprimentos formada pelos produtores rurais locais, cooperativas e escolas públicas que se beneficiam dos recursos do PNAE.

1.3 Composição da tese

O capítulo 1 traz a introdução, em que são abordados amplos aspectos sobre o tema. Traz informações que justificam e ressaltam a relevância da pesquisa, os objetivos gerais e específicos com os respectivos métodos utilizados. Traz ainda e a estrutura e a divisão do texto em capítulos.

O capítulo 2 traz embasamento téorico da temática baseado em referências de bases como *Science Direct* (Elsevier), *Emerald*, *Wiley* e *Scielo*, além de livros e relatórios governamentais. São tratatos referentes à cidade de Mogi das Cruzes e à atividade agrícola com foco em produtores familiares, *Short Food Supply Chains*, Programas de Alimentação Escolar e *Home Grown School Feeding*.

O capítulo 3 traz informações sobre a metodologia utilizada nesta pesquisa. São abordados os métodos empregados nas diversas fases metodológicas.

O capítulo 4 traz os resultados da produção científica desenvolvida para elucidar os objetivos específicos. Basicamente foram elaborados artigos científicos e um capítulo de livro. A figura 2 traz o *design* da pesquisa.

O capítulo 5 traz considerações finais, resultados obtidos de forma contextualizada, limitações da pesquisa e sugestão para estudos futuros.

Ao final estão as referências citadas em conformidade com a norma da Associação Americana de Psicologia (APA). A norma APA foi adotada para obedecer requisitos de editora Elsevier, facilitando a publicação dos conteúdos desta pesquisa em periódicos de impacto relevante.

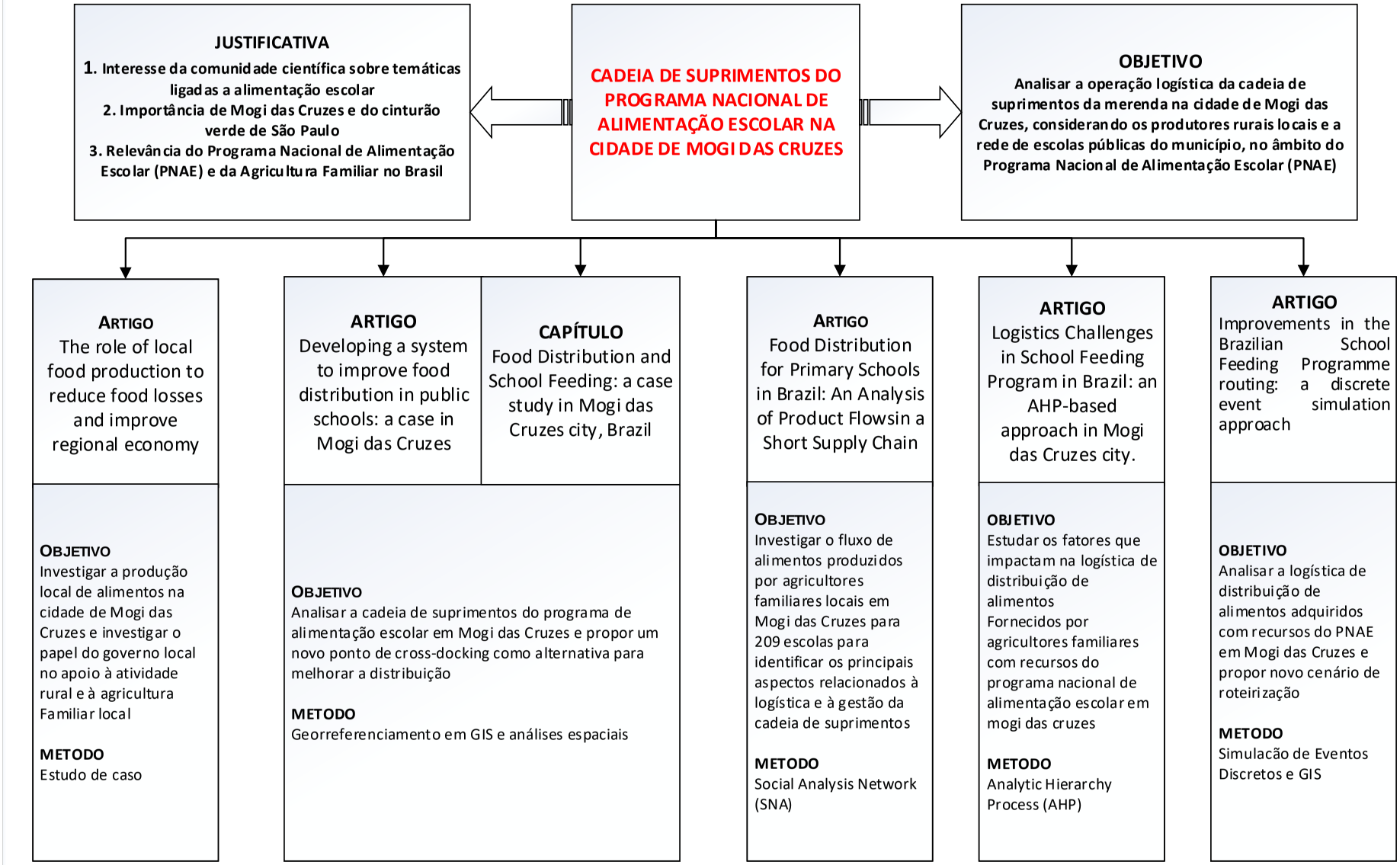


Figura 2: Design da pesquisa (autor)

2 Referencial teórico

Neste capítulo constam informações da literatura sobre as temáticas abordadas na pesquisa. Assuntos como agricultura familiar, programas de alimentação escolar no Brasil e no mundo, importância da cidade de Mogi das Cruzes e Cadeias de Suprimentos de Alimentos são discutidos.

2.1 Agricultura familiar e alimentação escolar

A Cúpula das Nações Unidas para o Desenvolvimento Sustentável definiu 17 Objetivos de Desenvolvimento Sustentável (ODS). Estão contempladas metas de até 2030, acabar com a fome e garantir o acesso de todas as pessoas, incluindo crianças, a alimentos seguros e nutritivos e suficientes durante todo o ano, acabar com a desnutrição e atingir até 2025 as metas acordadas internacionalmente sobre nanismo e caquexia em crianças menores de cinco anos de idade (Figura 3). Até 2030, a meta é dobrar a produtividade agrícola e a renda dos pequenos produtores de alimentos, particularmente das mulheres, povos indígenas, agricultores familiares, pastores e pescadores (ONU, 2015b; BRASIL, 2019).

Figura 3: Objetivos de Desenvolvimento Sustentável (BRASIL, 2019)

A agricultura familiar tem papel importante ao lado das grandes companhias do setor de agronegócio. Cerca de 90% das 570 milhões de propriedades rurais do

mundo são de pequeno porte, e a maioria se encontra nos países em desenvolvimento e são operadas por famílias. Muitos desses pequenos agricultores familiares têm acesso limitado a mercados e serviços, mas produzem alimentos para uma proporção substancial da população mundial. O triplo desafio de produzir mais alimentos, criar mais empregos e aumentar a base de recursos naturais coloca os pequenos agricultores familiares no centro da solução (FAO, 2019).

Pequenas propriedades rurais permitem contraditar a agricultura de larga escala, encorajando a adoção de arranjos que possibilitam a diversificação e a sustentabilidade econômica local. Podem ser construídas parcerias entre o governo federal e agricultores familiares, para que de forma conjunta, promovam meios de subsistência para esses produtores e para essa atividade econômica (Córdoba et al., 2018)

Assegurar a segurança alimentar é um dos maiores desafios do século 21 dos países em desenvolvimento (Berchin et al., 2019). Apesar da sua incapacidade de intervir nos mercados globais, as autoridades nacionais desempenham papel fundamental na garantia da segurança alimentar lidando com a produção de alimentos de grandes e pequenos produtores, promovendo sustentabilidade e inclusão social (Oosterveer et al., 2014).

Além de incrementar a disponibilidade de comida local, agricultores familiares desempenham papel vital na criação de empregos, geração de renda e diversificação da economia. Uma maneira para nutrir esse potencial, é conectar a produção agrícola familiar a mercados institucionais específicos como o fornecimento de refeições escolares. Essa combinação garante demanda e renda para agricultores familiares e refeições com valores nutricionais adequados para crianças, minimizando a mercantilização em massa das dietas (FAO, 2014).

O Brasil é um dos principais produtores de alimentos do mundo. O agronegócio brasileiro vem crescendo de forma relevante nas últimas quatro décadas (Chaddad, 2016) período em que a agricultura tem sido fundamental para economia do país, representando importante parcela da produção agrícola global (Borba et al., 2018).

No Brasil, a agricultura familiar é extremamente importante para a produção agrícola (Berchin et al., 2019). Em 2006 havia 5.175.489 propriedades produtoras no Brasil. Dentro esse universo de propriedades, 4.367.902 eram ligadas à agricultura familiar, representando quase 85% do total (Froehlich et al., 2018).

A maioria dos agricultores familiares no Brasil enfrenta dificuldades em termos de estrutura e de apoio de instituições, representando obstáculos ao seu desenvolvimento. Um estudo revelou que apenas 42,92% se matricularam em escolas, 62,31% têm um rendimento total de menos de um salário mínimo, apenas 12,77% se beneficiam de políticas agropecuárias e somente 5,45% pertencem a cooperativas (Medina et al., 2015). A Tabela 1 traz os percentuais de níveis educacionais dos chefes de família da agricultura familiar no Brasil e por regiões do país. Na tabela é possível

observar as disparidades entre as cinco regiões brasileiras.

Tabela 1: Percentual dos níveis educacionais dos agricultores familiares (Medina et al., 2015)

	Brasil	Norte	Nordeste	Centro Oeste	Sudeste	Sul
Analfabeto	26,74	20,06	42,55	10,42	12,67	5,05
Alfabetizado	5,57	10,54	5,5	7,05	5,59	2,96
Fundamental incompleto	42,92	47,45	29,98	50,55	49,45	66,68
Fundamental	7,78	7,32	4,93	11,72	11,23	11,49
Ensino Médio	4,81	3,31	3,15	8,48	7,6	6,54

A Tabela 2 traz o percentual por faixa de poder aquisitivo dos agricultores familiares no Brasil e por regiões. A Tabela traz dados classificados em extrema pobreza, baixa renda, entre 1 e 2 salários mínimos, entre 2 e 3 salários mínimos e acima de 3 salários mínimos.

Tabela 2: Poder aquisitivo de agricultores familiares (Medina et al., 2015)

	Brasil	Norte	Nordeste	Centro Oeste	Sudeste	Sul
Extrema Pobreza	6,13	5,16	10,16	1,87	4,3	0,87
Baixa renda	56,18	59,95	65,35	66,42	65,27	17,98
Entre 1 e 2 salários mínimos	22,58	16,95	15,06	23,51	20,82	44,94
Entre 2 e 3 salários mínimos	7,53	8,35	4,84	4,1	5,01	17,73
Acima de 3 salários mínimos	7,58	9,58	4,58	4,1	4,6	18,48

Módulo fiscal é uma unidade de medida, em hectares, cujo valor é fixado pelo INCRA para cada município considerando o tipo de exploração predominante (hortifrutigranjeira, cultura permanente, cultura temporária, pecuária ou florestal), renda obtida, outras explorações não predominantes mas expressivas em função da renda ou da área utilizada e o conceito de "propriedade familiar". O valor do módulo fiscal no Brasil varia de 5 a 110 hectares. Em Mogi das Cruzes, um módulo fiscal equivale a 5 hectares (EMBRAPA, 2019).

Para ser considerado agricultor familiar legalmente, o tamanho da propriedade não pode ultrapassar quatro módulos fiscais (Brasil, 2006). A maior parte das proprie-

dades estão entre 0 e 1 módulos fiscais. A Tabela 3 traz os percentuais do número de módulos fiscais das propriedades dos agricultores familiares.

Tabela 3: Percentual do tamanho das propriedades em módulos fiscais (Medina et al., 2015)

	Brasil	Norte	Nordeste	Centro Oeste	Sudeste	Sul
0–1	83,07	79,98	92,31	71,56	75,82	71,53
1–2	10,99	14,32	5,04	16,47	14,54	19,32
2–4	5,94	5,7	2,65	11,97	9,65	9,15

O papel do Estado é crucial na concepção de políticas agrícolas que apóiam o desenvolvimento rural familiar. O governo federal do Brasil estabeleceu em 2006 a Política Nacional da Agricultura Familiar e Empreendimentos Familiares Rurais, por meio da lei 11.326, que define agricultores familiares de acordo com quatro critérios: não possuir mais do que quatro módulos fiscais, cuja área varia de acordo com o município, utilizar apenas mão-de-obra da família nas atividades do seu empreendimento, tenha percentual mínimo da renda familiar originada de atividades econômicas do seu estabelecimento e dirija seu empreendimento com sua família (Brasil, 2006).

Na esfera política, a agricultura recebeu apoio por meio da inclusão de compras de alimentos pelo Programa de Aquisição de Alimentos (PAA) e do Programa Nacional de Alimentação Escolar (PNAE), além do Programa Mais Alimentos (Guanziroli & Di Sabbato, 2014).

Dentre as ações governamentais do governo federal brasileiro para se garantir a segurança alimentar, uma das mais impactantes é o Programa Nacional de Alimentação Escolar (PNAE). A Tabela 4 traz algumas ações dessa natureza do governo brasileiro (Berchin et al., 2019).

O Fundo Nacional de Desenvolvimento da Educação (FNDE), é uma autarquia federal responsável pela execução de políticas educacionais do Ministério da Educação (MEC). O FNDE promove repasses de recursos para estados e municípios por meio dos programas ativos de Alimentação Escolar, Livros Didáticos, Dinheiro Direto na Escola, Biblioteca da Escola, Transporte Escolar, Caminho da Escola, e Reestruturação e Aquisição de Equipamentos para a Rede Escolar Pública de Educação Infantil (FNDE, 2019b).

Do total de recursos transferidos pelo Fundo Nacional de Desenvolvimento da Educação (FNDE) por meio do Programa Nacional de Alimentação Escolar, pelo menos 30% devem ser utilizados na compra de alimentos da agricultura familiar, seja diretamente dos agricultores ou de seus representantes (Brasil, 2009). De acordo com as recomendações do FNDE, o cardápio da alimentação escolar deve ser programado para atender a pelo menos 20% do valor nutricional das necessidades diárias

Tabela 4: Ações do governo brasileiro (Berchin et al., 2019)

Programa	Meta	Resultados	Ano
Programa Nacional de Alimentação Escolar (PNAE)	Cobrir necessidades nutricionais de crianças e jovens em fase escolar	41,5 milhões de estudantes atendidos e investimento de 2,35 bilhões de dólares em 2015	1955
Programa Nacional de Fortalecimento da Agricultura Familiar	Financiar projetos individuais e coletivos para geração de renda e assentamento de famílias em terras	7,5 bilhões de dólares investidos em 2015	1995
Programa de Aquisição de Alimentos (PAA)	Encorajar a agricultura familiar e o acesso de alimentos a pessoas com insegurança alimentar	146.960.000 dólares investidos em 2015	2003

dos alunos. É meta do PNAE que se garanta em média, 300 kcal e 9,4 g de proteínas (Nogueira et al., 2016).

Para serem considerados ativos no PNAE, os agricultores familiares devem possuir a Declaração de Aptidão ao Pronaf (DAP). Os agricultores podem participar de forma individual ou organizados em grupos informais, com a DAP física, ou por meio de organizações formais, como associações e cooperativas com a DAP jurídica (FND, 2016).

Ao longo da última década, o Brasil construiu parceria com o Centro de Excelência contra a Fome e com a Organização das Nações Unidas para Alimentação e Agricultura (FAO). Os projetos da cooperação *South-South* são baseados na troca de experiências entre nações, e envolvem 33 países da África e 13 países da América Latina e Caribe. O Dia Africano da Alimentação Escolar foi estabelecida em 2016 após visita da delegação da União Africana ao Brasil para conhecer a abordagem do Programa Nacional de Alimentação Escolar (FNDE, 2019c).

2.2 Produção local de alimentos e *Short Food Supply Chains*

A insegurança alimentar é um problema que ocorre em muitas áreas urbanas e tem sido relacionada a problemas de saúde, como diabetes, pressão arterial elevada e obesidade infantil. Frutas e legumes frescos são essenciais para vidas saudáveis e para as economias locais. No entanto, alimentos frescos não estão disponíveis para todos os cidadãos (Moak et al., 2018).

Embora sistemas convencionais de produção e distribuição de alimentos sejam

produtivos e entreguem quantidades maciças de alimento a baixos preços, grandes produtores usam mais fertilizantes e pesticidas. Dado o tamanho e a intensidade da produção, esses sistemas não são sustentáveis e representam uma ameaça à integridade dos ecossistemas. Sistemas alternativos promovem a conexão entre consumidores e produtores, e fomentam benefícios econômicos e sociais da produção agrícola local, operado por pequenos produtores locais (Mundler & Criner, 2016).

A globalização dos mercados e a facilidade na circulação de produtos de gênero alimentício podem estar associados a eventual perda da origem geográfica dos alimentos, fato que pode expor os consumidores a riscos, uma vez que os produtos importados podem ser provenientes de países em que normas e leis de qualidade e segurança são menos rigorosas (Bandoniene et al., 2018).

Devido à globalização no comércio, a distância de viagem dos alimentos aumentou notavelmente. Embora permita a disponibilidade constante de alimentos, independentemente das condições sazonais, é crescente a preocupação com a transparência e a segurança do que se consome, já que é difícil entender a complexa dinâmica das cadeias de suprimentos de alimentos atuais (Meyerding et al., 2019).

Estudos têm sido conduzidos abordando cadeias de suprimentos de alimentos que conectam produtores locais de forma direta com consumidores (Mundler & Laughrea, 2016; Aubry & Kebir, 2013; Oñederra-Aramendi et al., 2018; Chiffoleau et al., 2019).

Cadeias locais urbanas e periférico-urbanas de suprimentos fornecendo produtos frescos estão surgindo para atender a crescente demanda de alimentos mais saudáveis cultivados localmente, e também para fomentar a sustentabilidade dos sistemas produtivos locais, beneficiando todos seus *stakeholders* (Nakandala & Lau, 2018).

O termo *short food supply chains* tem sido utilizado para definir cadeias em que alimentos são produzidos perto dos consumidores (Skallerud & Wien, 2019; Sage, 2003). (Charatsari et al., 2018) afirmam que o termo *short food supply chain* foi incluído na literatura científica por (Marsden et al., 2000), como uma alternativa às longas cadeias de suprimentos de alimentos que focam no produto industrializado, mudando as atenções para a qualidade da relação produtor-consumidor, e no potencial de ressocializar os alimentos (Sonnino & Marsden, 2006). SFSCs derivam de origens ecológicas ou regionais, que foram estabelecidas para “encurtar” as cadeias tradicionais, ou para a desenvolver redes alternativas que proporcionem oportunidades de desenvolvimento rural em termos de valor agregado (Marsden et al., 2000).

As SFSCs representam uma abordagem de rede alternativa não apenas relativa à distribuição de produtos agrícolas, mas também objetivam a promoção de novos padrões de produção e consumo, servindo como um meio de diminuir a lacuna entre agricultores e consumidores (Charatsari et al., 2018). A Tabela 5 traz comparações dos sistemas convencionais e locais de produção e distribuição de alimentos.

Tabela 5: Comparação entre sistemas convencionais e sistemas locais de produção e distribuição de alimentos (Mundler & Criner, 2016)

	Sistema convencional	**SFSCs**
Formas de melhorar ganhos do produtor	Especialização, escala, menores custos	Diversificação, menos intermediários entre produtor e consumidor para captar maior valor
Divisão do trabalho	Alto grau de especialização e concentração do trabalho	baixo nível de especialização e trabalhadores com atividades fragmentadas
Qualidade do produto	Produtos padronizados se adequam ao processo industrial, alto nível de processamento, qualidade consistente	Mix menos homogêneo, produtos menos processados, frescos e mais saborosos, autenticidade do produto relacionaa com a identificação geográfica
Mercado-alvo	Fornecimento em massa e diferenciação tecnológica	Consumidores próximos com identificação local
Objetivos de desempenho	Preço competitivo, melhoria da produtividade do trabalho e da terra	Competição pela qualidade, ênfase no frescor e sabor, sustentabilidade pela colheita rotativa e planejamento de colheitas múltiplas
Requisitos desejados em relação á área de produção	Densa e concentração em áreas com alto potencial agrícola	Dispersão devido à rotatividade de colheitas e colheitas múltiplas
Distâncias percorridas (Food Miles)	Longas	Curtas
Funções da agricultura	Primoridalmente produzir matérias-primas para indústria	Múltiplas funções como produzir alimentos, prover emprego e renda, auxiliar a sustentabilidade da economia rural

Ao longo das últimas décadas tem ocorrido movimento de realocação intensa das comunidades e economias locais, em parte como resposta às injustiças econômicas e concentração global de capital e ao empreendedorismo buscando atender demanda por ética análoga aos produtos e serviços consumidos (Mars & Schau, 2018). Estudos que envolvem a produção local de alimentos podem ser motivados pela busca de enfatizar políticas para fomentar o consumo de alimentos produzidos localmente baseando-se na premissa de bem-estar social, reduções nas distâncias percorridas por alimentos no transporte (*food miles*), qualidade ambiental e saúde pública (Berg & Preston, 2017).

A produção local de alimentos é parte importante da cultura e há a percepção de que é mantida em consideração pelas comunidades locais (Skallerud & Wien, 2019). O consumo de alimentos produzidos localmente é uma tendência, especialmente em países desenvolvidos. No geral, consumidores demonstram percepção positiva em relação aos alimentos produzidos localmente. Quando a compra é realizada diretamente do produtor, o consumidor tem sensação de segurança por meio do contato direto com a fonte produtora (Prior & Penney, 2014; Aprile et al., 2016).

A proximidade geográfica da produção e os benefícios econômicos e informações regulares sobre as vantagens do consumo de alimentos locais devem estar entre as principais considerações para políticas que pretendam incentivar o consumo de alimentos locais (Berg & Preston, 2017).

Estudar os consumidores de alimentos locais requer uma abordagem contextualizada e a compreensão das atividades de produção de alimentos. O termo *local food* tem sido utilizado para descrever sistemas produtivos locais (Khan et al., 2019).

O termo *local food* encontrado por diversas vezes na literatura pode significar diferentes visões (Nakandala & Lau, 2018), variando entre questões geográficas e culturais (Meyerding et al., 2019; Prior & Penney, 2014; Jones et al., 2004; Aaltojärvi et al., 2017). Um exemplo de definição é dada pela *US Food Conservation and Energy Act 2008*, sendo que o alimento local e regional é cultivado, produzido e distribuído dentro de área com distância total de transporte inferior a 400 milhas da origem até o ponto de consumo (Nakandala & Lau, 2018). Uma pesquisa levantou a definição do termo *local food* de um grupo de consumidores de alimentos (Meyerding et al., 2019) em que respondentes tinham liberdade de opção por uma ou mais alternativas propostas. Os percentuais obtidos pelas respostas de cada definição são mostrados na Figura 4.

Estimar de forma abrangente as vantagens da produção local de alimentos pode ser tarefa complexa, devido ao fato de que há inúmeras abordagens que levam à percepção de como esses sistemas beneficiam a economia. Menor consumo de combustível no transporte de alimentos e consequente contribuição para o meio ambiente pode ser um exemplo (Khan et al., 2019), mas também há benefícios no uso

Figura 4: Definição de *local food* na visão dos respondentes (Meyerding et al., 2019)

de recursos naturais como a água utilizada para irrigação e na mudança dos hábitos alimentares (Yang & Campbell, 2017).

Os benefícios da produção local de alimentos percebidos pelos consumidores são tipicamente como sendo alternativas de alimentação "mais fresca", "mais saudável"e "de melhor qualidade". Para que produtores locais prosperem dentro da competição mercadológica, é fundamental que além da promoção, comercialização e distribuição, que os consumidores urbanos sejam conscientizados sobre o que é realmente o alimento local e seus benefícios (Prior & Penney, 2014). SFSCs abrem oportunidades para a agricultura urbana local que está gravemente ameaçada pela concorrência global e expansão urbana. O fornecimento de alimentos para áreas urbanas pode ser uma forma de manter ou desenvolver outras agriculturas locais especializadas como flores e frutas (Aubry & Kebir, 2013).

A Tabela 6 traz pesquisa realizada com o intuito de captar a percepção dos consumidores acerca de alimentos produzidos por agricultores locais. Os resultados evidenciam que os participantes da pesquisa têm alto grau de concordância a respeito dos aspectos positivos aos quais foram inquiridos (Aprile et al., 2016).

Tabela 6: Percepção acerca dos alimentos produzidos localmente (Aprile et al., 2016)

	discordo fortemente (%)	discordo (%)	nem concordo nem discordo (%)	concordo (%)	concordo fortemente (%)
Mais saborosos	1,6	6,8	5,7	57,8	28,1
Mais saudáveis	0,5	6,3	9,4	58,9	25
Têm qualidade superior	0,5	6,8	12,5	53,6	26,6
Mais naturais	1	5,7	9,4	60,4	23,4
Asseguram menor impacto ambiental	1,6	7,8	10,4	61,5	18,8
Ajudam sustentar agricultura local	3,1	14,1	14,5	47,9	20,4
Apoiam os agricultores familiares	2,6	15,1	12,9	50,5	18,9
Mantém métodos tradicionais de produção	11	16,7	12,4	40,5	19,4
Reduzem distância de transporte	0,5	5,7	4,2	59,9	29,7
Não necessitam longas viagens	2,1	4,7	6,8	59,5	26,6

Do ponto de vista dos produtores, a disposição em participar de SFSCs é maior em indivíduos que exibem elevados níveis de cidadania, indicando que a participação em sistemas alternativos de distribuição de alimentos também tem aspectos psicológicos. Além disso, agricultores que se sentem aceitos nas redes de colaboração intracomunitárias e desfrutam de sensação de proximidade enquanto interagem com sua comunidade, estão mais dispostos à participação (Charatsari et al., 2018).

2.2.1 Gestão das Cadeias de Suprimentos de Alimentos

Apesar da importância do setor de alimentos, o gerenciamento de cadeias de suprimento alimentares recebe menor atenção da literatura. A razão pode ser a complexa gestão dessas cadeias e a especificidade dos produtos e processos (Rong et al., 2011).

O desempenho do transporte das cadeias de suprimento globais é superior

quando se compara com cadeias locais. Além das distâncias, o modo de transporte, a eficiência do sistema de distribuição e a capacidade de carga dos veículos têm impacto na operação logística (Schmitt et al., 2017).

Muitos pequenos agricultores vivem em áreas remotas com infraestrutura rodoviária deficitária, criando altos custos de transação para acessar mercados da alimentação escolar. Falta de diversidade de produtos e práticas inadequadas de manuseio e armazenagem pós-colheita geram dificuldades para agricultores no cumprimento de requisitos de qualidade dos programas de alimentação escolar (Maijers & Nalla, 2014).

Há grandes desafios para os agricultores que operam em sistemas locais de produção de alimentos, como o acesso limitado à tecnologia, necessidade de condução de novas redes e alianças, projetar estratégias de distribuição para ampliar o alcance geográfico e operar de forma mais econômica e geograficamente acessível para clientes atuais e potenciais (Mars & Schau, 2018).

Dentre os fatores críticos de sucesso das SFSCs, ainda que existam componentes culturais, a principal motivação ainda é econômica – cortar custos de transporte e eliminar agentes intermediários que geram importantes gastos na operação das cadeias de suprimentos de alimentos, ainda que maior atenção venha sendo atribuída a questões relativas à qualidade, a relações mais estreitas com consumidores e à proteção ao meio ambiente (Sellitto et al., 2018).

Há alto grau de variação na deterioração da qualidade em todos os tipos de produtos frescos e também variam as condições de armazenamento e transporte necessárias (Nakandala & Lau, 2018). Diminuir os tempos de estocagem e transporte representa grande desafio para evitar a deterioração de alimentos frescos. A Figura 5 traz a configuração de uma *food supply chain* genérica, com os pontos possíveis de deterioração, durante a estocagem e o transporte (Rong et al., 2011).

Uma abordagem para promover ganhos de escala na operação logística nas cadeias de suprimento de alimentos regionais é implementar as melhores práticas que produziram altos níveis de eficiência e eficácia em cadeias de suprimentos globais. Tais práticas incluem desenvolvimento e coordenação de relacionamento em toda a cadeia de suprimentos, utilização eficiente de infraestrutura de transporte e logística, implementação de sistemas precisos e confiáveis para rastreabilidade de alimentos e planejamento de demanda orientada por dados (Mittal et al., 2018).

Estudos logísticos sobre *Food Miles* com base em medições reais, examinam distâncias específicas percorridas e a eficiência energética ou outros impactos ambientais em cada estágio da cadeia de suprimentos, da produção ao consumo (Mundler & Criner, 2016). O transporte dentro da *last food mile* representa parte importante e problemática das *Food Supply Chains* devido aos custos e do elevado número de atores interessados envolvidos, e as variáveis mais significativas são a forma de entrega, a frequência de entregas e os tipos de veículos utilizados (Fancello et al., 2017).

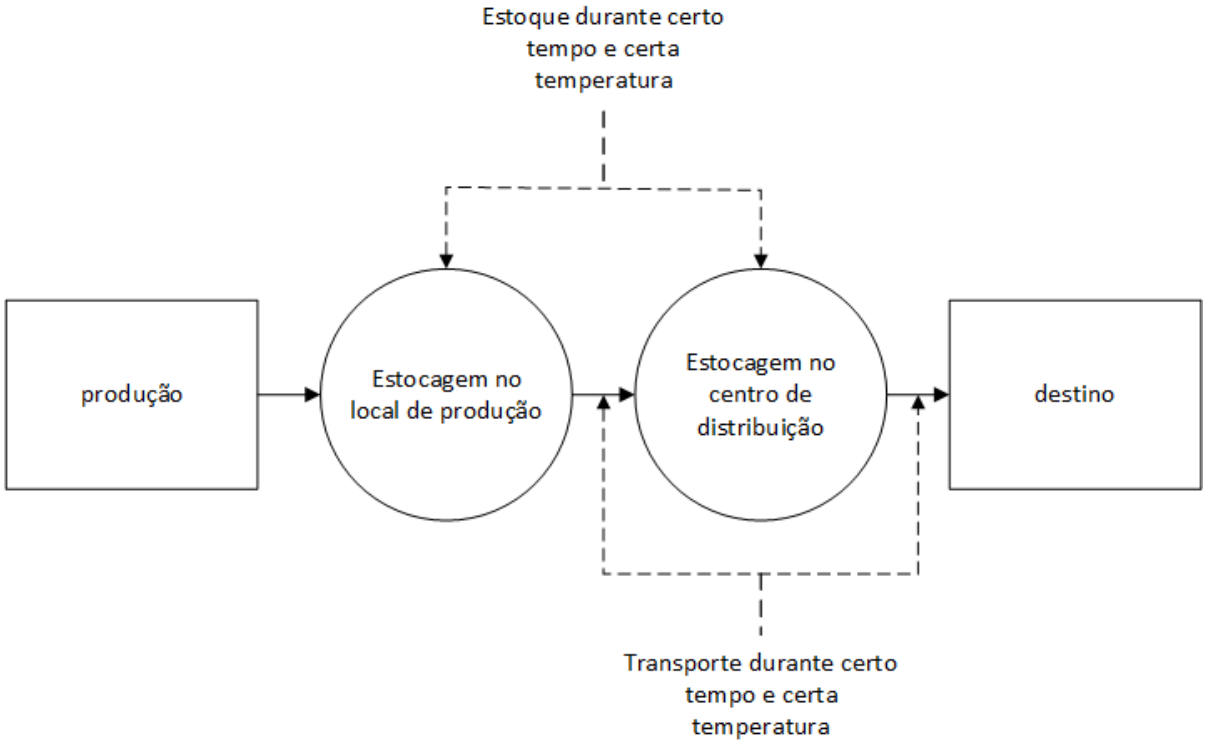


Figura 5: *Food supply chain* genérica (Rong et al., 2011)

As maiores ineficiências logísticas associadas ao frete local de alimentos estão no início e no fim da cadeia de suprimentos, em que inúmeras rotas de *first* ou *last mile* são curtas mas muito custosas, e oneram o custo de transporte por unidade (Day-Farnsworth & Miller, 2014). Pequenos agricultores costumam usar seus veículos pessoais ou vans, ao invés de transportadoras comerciais (Mundler & Rumpus, 2012).

A contribuição das SFSCs para a melhoria da eficiência energética tem sido debatida nos últimos anos. É possível estabelecer ligação entre a redução de distâncias percorridas por alimentos e menor consumo de combustível no transporte. Por outro lado, existe a percepção de que essas cadeias de suprimentos de alimentos locais têm um fraco desempenho energético pelo baixo nível de qualificação em logística dos envolvidos (Mundler & Rumpus, 2012).

Vistos na perspectiva dos atores e instituições responsáveis pelos programas de alimentação escolar como um todo, processos da cadeia de suprimentos incluem *procurement*, distribuição, recursos humanos e informações (Gelli et al., 2012):

- *Procurement* : identificação, seleção, contratação, gestão e desenvolvimento de fornecedores
- Distribuição: operações de entrega (transporte e armazenagem), podendo incluir preparação de refeições; a entrega é aspecto crucial das operações de alimentação escolar e requer capacitação em operações de distribuição e planejamento de transporte

- Recursos Humanos e informações: pessoas e ferramentas de Teconologia da Informação (TI) utilizadas para facilitar os processos da cadeia de suprimentos, como planejar e gerenciar finanças, indicadores, avaliação e relatórios; competências e qualificação em logísticas são de particular importância

No caso do PNAE, houve alto grau de centralização, com o governo controlando desde o planejamento de cardápios até a aquisição, armazenamento e distribuição de alimentos. Esse sistema recebeu reclamações sobre a qualidade dos alimentos e sobre ineficiências dos processos de distribuição. O programa foi descentralizado em 1994. Os Estados e municípios passaram a ser responsáveis pela gestão e implementação do PNAE (Lesley et al., 2016).

Modelos decisórios podem ser sugeridos para diminuir custos de transporte, com vários destinos são atendidos a partir de um centro de distribuição (Soto-Silva et al., 2017).

Cadeias de suprimentos da alimentação escolar podem ser caracterizadas em termos do nível de descentralização na gestão de suprimentos, distribuição, monitoramento, e o uso de terceiros (Lesley et al., 2016):

- Centralizado: gestão da cadeia de suprimentos ocorre em nível nacional e é realizada internamente pelo governo
- Semi-descentralizado: gestão da cadeia de suprimentos realizada internamente por escalões menores do governo
- Descentralizado: gestão da cadeia de suprimentos ocorre em nível local ou pelo governo ou pela escola
- Terceirizado centralizado: a gestão da cadeia de suprimentos ocorre em nível central, estadual ou nacional por um terceiro
- Terceirizado semi-descentralizado: gestão da cadeia de suprimentos de responsabilidade de escalões menores do governo realizado por terceiros
- Terceirizado descentralizado: gestão da cadeia de suprimentos ocorre em nível local ou escolar pelo setor privado.

A Tabela 7 mostra modelos da cadeia de suprimentos de alimentação escolar utilizados em diferentes países em que nenhum dos casos foi adotado modelo centralizado terceirizado (Gelli et al., 2012).

Menus servidos em programas de alimentação escolar requerem processamento básico dos ingredientes. Pequenos agricultores e organizações familiares têm

Tabela 7: Modelos de Cadeias de Suprimentos (Gelli et al., 2012)

Modelo da Cadeia de Suprimentos (School Feeding Supply Chain)	**País**
Centralizado	Botswana, Cabo Verde, Equador, Namíbia
Semi-descentralizado interno	Brasil, India, Mali, México, África do Sul
Descentralizado interno	Costa do Marfim, Kênia
Centralizado terceirizado	-
Semi-descentralizado terceirizado	Chile
Descentralizado terceirizado	Gana, Nigéria (*Osun State*)

instalações com falta de capacidade e de qualidade de armazenamento, fato que representa oportunidade para comerciantes comprarem produtos a baixos preços. Grandes fornecedores têm capacidade de armazenamento suficiente e são atraentes pelo fornecimento regular a preços relativamente baixos. Instalações adequadas em classificação e embalagem devem ser disponibilizados para agricultores locais. Organizações e cooperativas poderiam oferecer a estrutura necessária para que agricultores familiares sejam competitivos para fornecer para os programas de alimentação escolar (Maijers & Nalla, 2014).

2.3 Programas de Alimentação Escolar

Todos os dias muitos homens e mulheres em todo o planeta lutam para alimentar seus filhos. Em um mundo em que se produz comida suficiente para alimentar a todos, 821 milhões pessoas – uma em cada nove – ainda não têm acesso à alimentação. Uma em cada três pessoas sofre de alguma forma de desnutrição (WFP, 2019b). A Figura 6 mostra os níveis de desnutrição no mundo (WFP, 2019c).

Erradicar a fome e a nutrição insuficiente é um dos grandes desafios do nosso tempo. Em 2015, a comunidade global adotou 17 objetivos para o desenvolvimento sustentável para melhorar a vida das pessoas até 2030, dentre os quais consta a meta 2, que visa acabar com a fome, alcançar a segurança alimentar, melhorar a nutrição e promover a agricultura sustentável (WFP, 2019c; ONU, 2015b).

Metade dos alunos do mundo, cerca de 310 milhões, em países de baixa e meia-renda recebem refeições diárias na escola. Há estimativas e estudos demonstrando que na Índia são alimentadas mais de 100 milhões de crianças, no Brasil 48 milhões, na China 44 milhões, na África do Sul e Nigéria mais de 9 milhões em cada país. Nos últimos dez anos, houve um crescente consenso global de que programas de alimentação escolar geram impacto duradouro no progresso das nações (WFP,

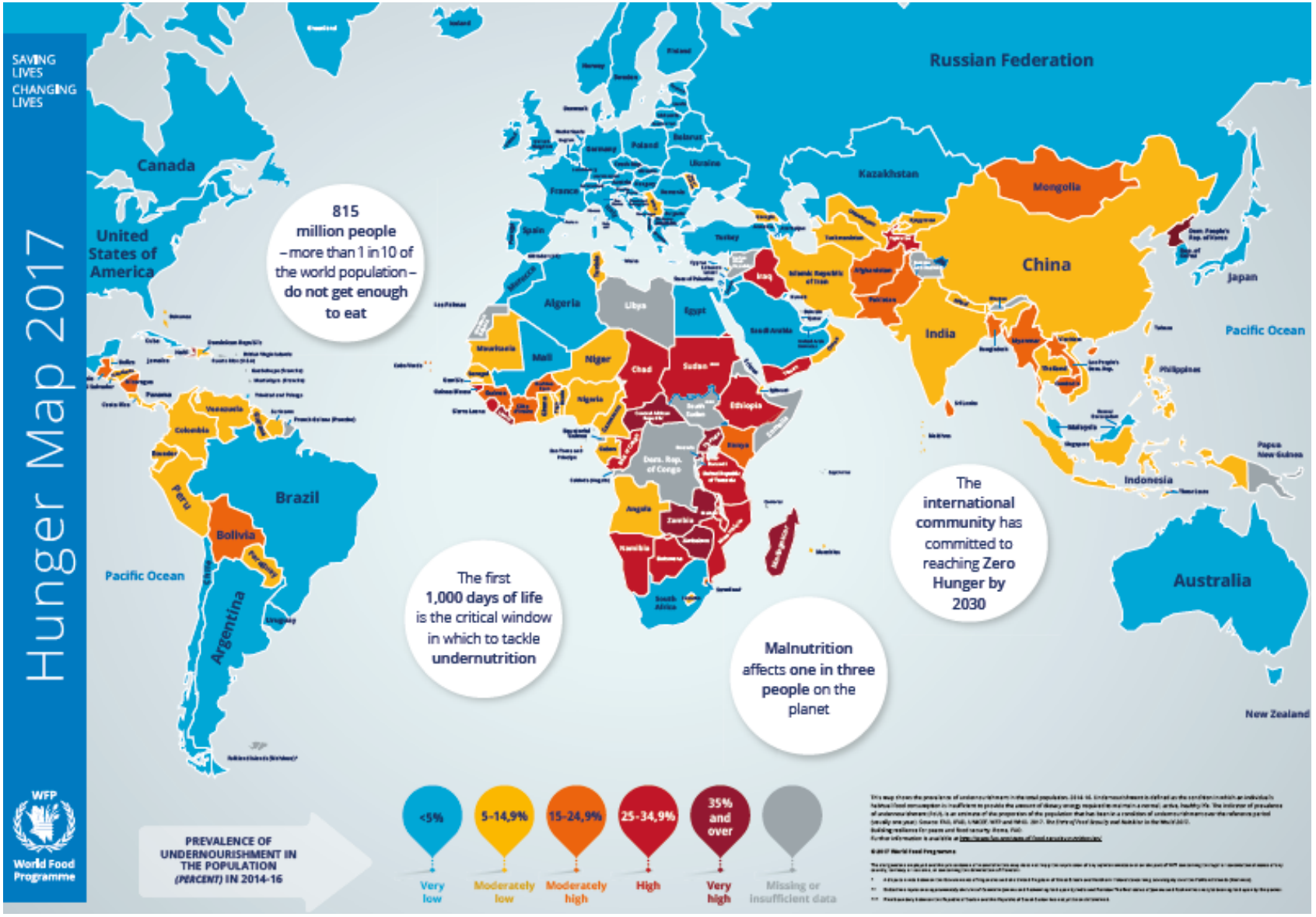


Figura 6: Mapa da fome (WFP, 2019c)

2019b).

O *Midday Meal Scheme* na Índia é o maior programa de alimentação escolar do mundo, alimentando 105 milhões de crianças diariamente (WFP, 2017). A Figura 7 traz a evolução do número de alunos atendidos pelo programa de alimentação escolar indiano, demonstrando que o esforços do governo são crescentes (PCD, 2011).

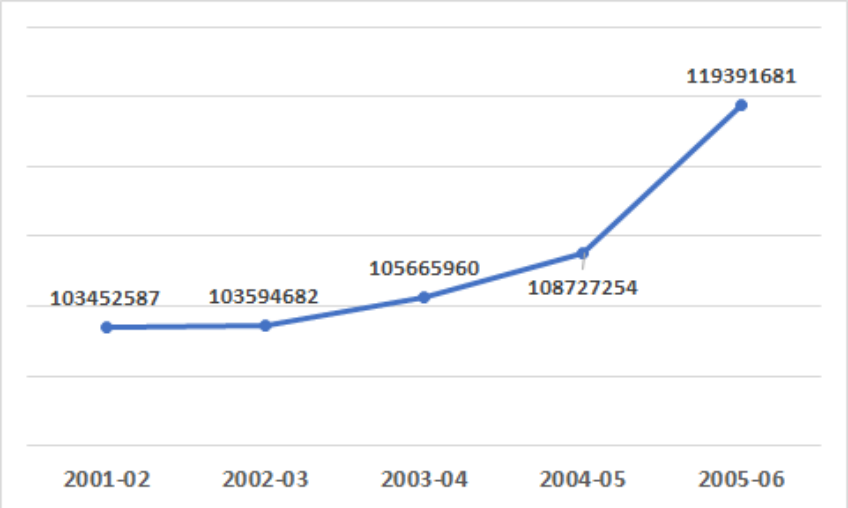


Figura 7: Número de alunos atendidos pelo programa indiano (PCD, 2011)

Em Mali, a alimentação escolar existe desde a sua independência na década de 1960, e é reconhecida como uma das formas mais eficientes de apoiar a educação das crianças. O primeiro programa organizado para alimentação escolar remonta a 1999. O papel do estado em Mali foi ampliado. Até 2008 apenas apoiava programas de alimentação escolar implementados por parceiros, e um coordenador nacional e agentes do governo eram responsáveis pelo acompanhamento dos programas implementados. Atualmente o estado fornece suprimentos, equipamentos de cozinha e apoia a restauração e construção de cozinhas em 651 escolas (HGSF, 2019a).

As crises financeiras, de alimentos e do petróleo, que se iniciaram em 2008, culminaram em mudanças na visão do papel da alimentação escolar dentro da comunidade desenvolvimentista, com maior reconhecimento de que esses programas geram benefícios nos setores de saúde, educação, social e agricultura. A Figura 8 ilustra os principais marcos nessa mudança de paradigma (Bundy et al., 2018).

O fornecimento de refeições nas escolas ampara os alunos matriculados e promove a assiduidade. A alimentação oficializa o aluno como um membro da comunidade escolar e amplia sua motivação para comparecer todos os dias à escola. Programas de alimentação escolar buscam amenizar os efeitos negativos que a fome traz para o processo de aprendizagem. Crianças famintas têm menor energia ou motivação e suas habilidades de pensamento são afetadas, gerando déficit de concentração. A fome impede que crianças pobres ou famintas tenham direito à educação, e é um

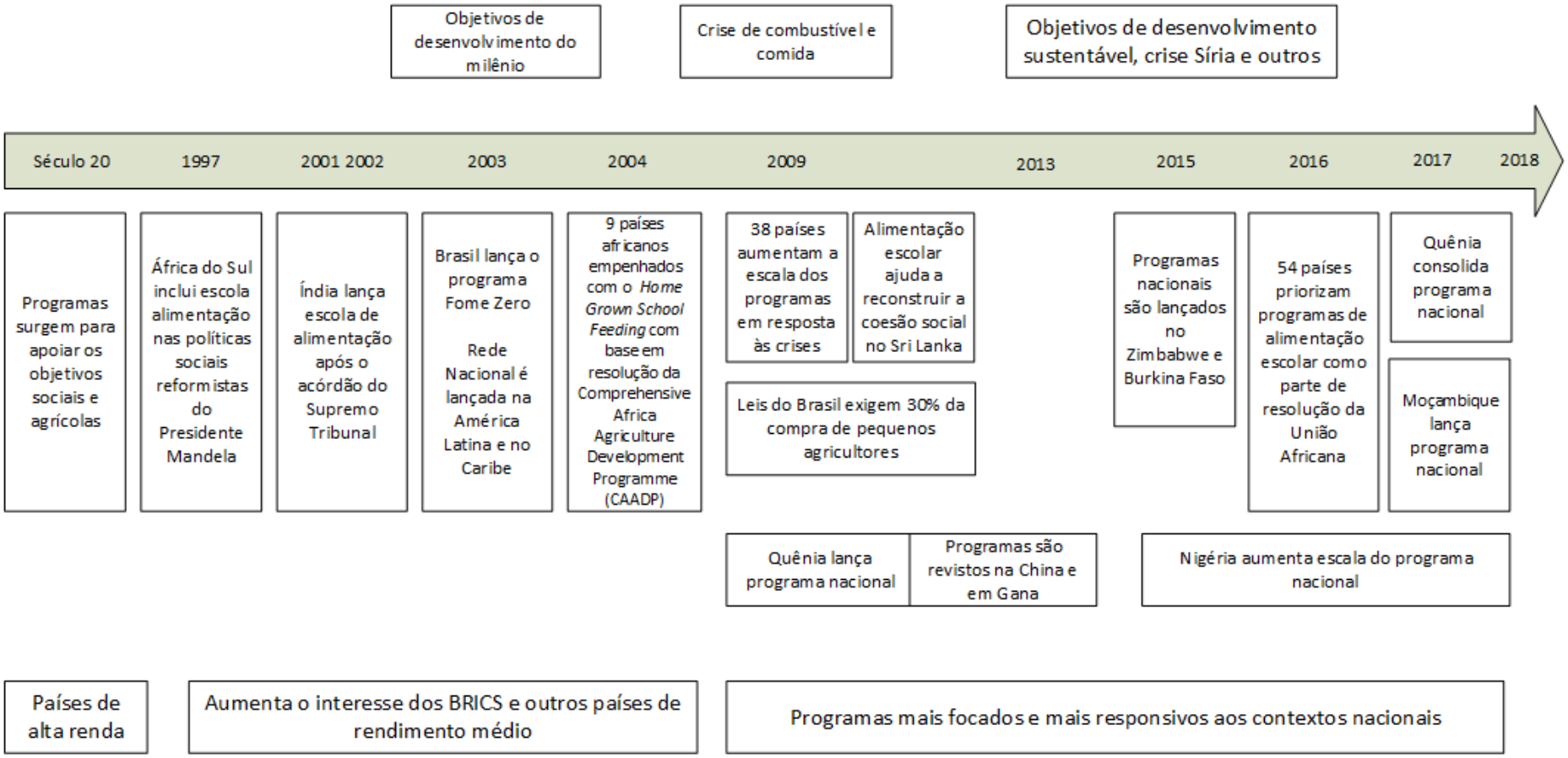


Figura 8: Evolução dos programas de alimentação escolar (Bundy et al., 2018)

dos principais alvos de programa de alimentação escolar (Iddrisu et al., 2019).

Há aproximadamente 500 milhões de pequenos agricultores no mundo, que produzem a maior parte dos alimentos em países de baixa e média renda, incluindo 80% dos alimentos consumidos na Ásia e na África Subsaariana. Muitos desses agricultores têm filhos na escola. Ao vinculá-los aos programas de alimentação escolar, protege-se essa atividade com renda regular e garantida (HGSF, 2019b).

O *Centre of Excellence against Hunger* foi lançado em conjunto com Programa Mundial de Alimentos e no Brasil em 2011, para ser o principal fórum da *South-south cooperation* no combate a fome e a desnutrição. O centro baseia-se na experiência brasileira para compartilhar conhecimento e inovações políticas entre os países em desenvolvimento, focando-se na vinculação dos programas de alimentação escolar à agricultura local (WFP, 2019a).

Países africanos têm procurado ampliar programas de alimentação escolar baseados na experiência do Brasil, que reduziu os impactos da pobreza por meio da alimentação escolar. O Brasil é hoje um modelo em todo o mundo na implementação do programa de alimentação escolar sem interferência política (Iddrisu et al., 2019; Sonnino et al., 2014).

Um exemplo é o Programa de Alimentação de Escolar de Gana (*Ghana School Feeding Programme*). O programa do país africano tem a colaboração da *World Food Programme* (WFP), *Partnership for Child Development* (PCD) e da *United Nations Educational*, Scientific and Cultural Organization (UNICEF). Também colaboram com o programa a *Canadian International Development Agency* (CIDA), a *US Agency for International Development* (USAID) e a *Dutch Embassy* (Zaney, 2019).

A Figura 9 mostra os distritos atendidos pelo programa de alimentação escolar de Gana no período 2014/2015 representados pela cor escura do mapa (HGSF, 2016). Nota-se que boa parte do país ainda não é beneficiada com o programa.

A Tabela 8 mostra o alcance do programa por distrito do país (Iddrisu et al., 2019). Os dados mostram que há grande variação de alcance percentual dos alunos beneficiados no período estudado entre os diferentes distritos de Gana.

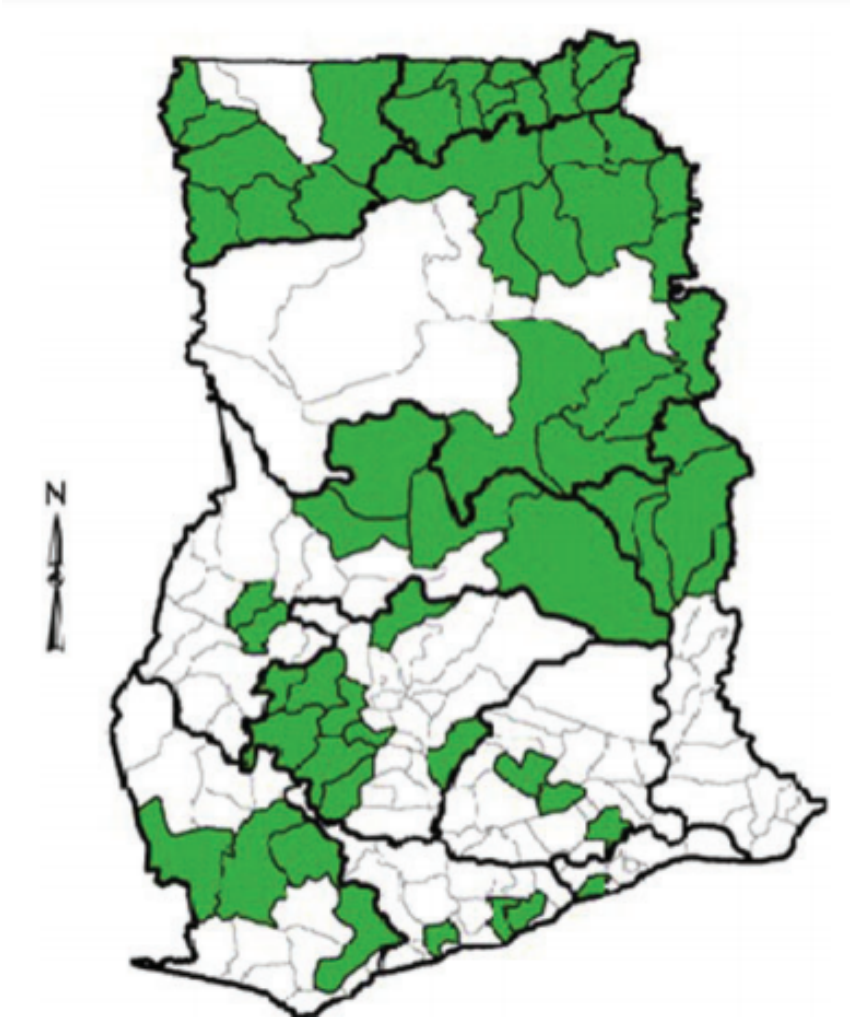


Figura 9: Distritos de Gana atendidos (HGSF, 2016)

Tabela 8: Alcance do programa de alimentação escolar em Gana (Iddrisu et al., 2019)

Região	Alunos da educação básica	Percentual de alunos beneficiados pelo programa de alimentação escolar	Alunos beneficiados pelo programa de alimentação escolar
Ashanti	727.659	43,57	335.293
Brong Ahafo	494.033	37,28	194.074
Central	424.567	21	88.229
Eastern	472.299	24,28	118.388
Greater Accra	316.726	59,72	193.439
Northern	578.106	31,33	203.679
Upper East	263.234	56,67	159.882
Upper West	183.141	90,43	176.587
Volta	406.637	28,59	125.345
Western	498.208	27,21	133.765

Há uma longa tradição de programas de alimentação escolar na America Latina e Caribe (Figura 10). Todos países da região implementaram programas nacionais de alimentação escolar, com exceção de Belize. Os programas mexicano, costa-riquenho e colombiano, estão entre os mais antigos do mundo. Outros como os programas da Bolívia, do Chile, do Haiti, de Honduras e da Guatemala, têm suas origens em meados do século XX. O Paraguai iniciou o programa com pequena escala em 1995, e o novo programa nacional lançado em 2014 atingiu segundo estimativas 95% dos alunos da educação básica em 2016 (WFP, 2017). Os Programas de Alimentação Escolar na América Latina tiveram início no começo do século XX, com o programa Uruguaio. Brasil, Argentina e Chile criaram seus programas no início das décadas de 1950 e 1960 (Lopes et al., 2017).

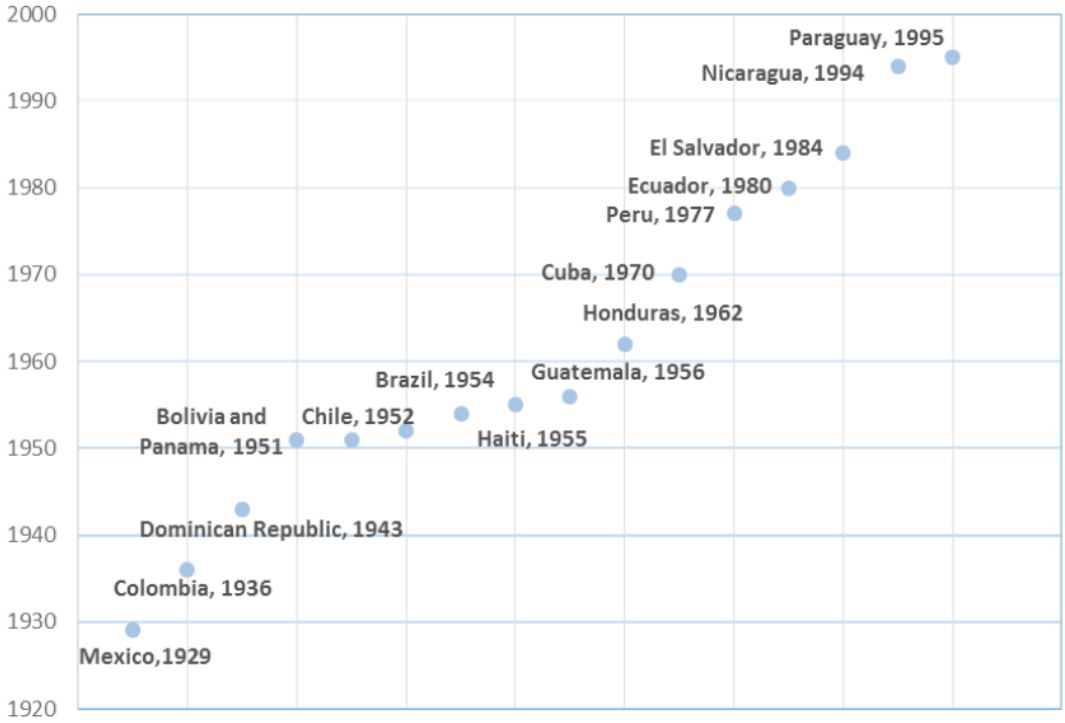


Figura 10: Implantação dos programas de alimentação escolar na região da América Latina e Caribe (WFP, 2017)

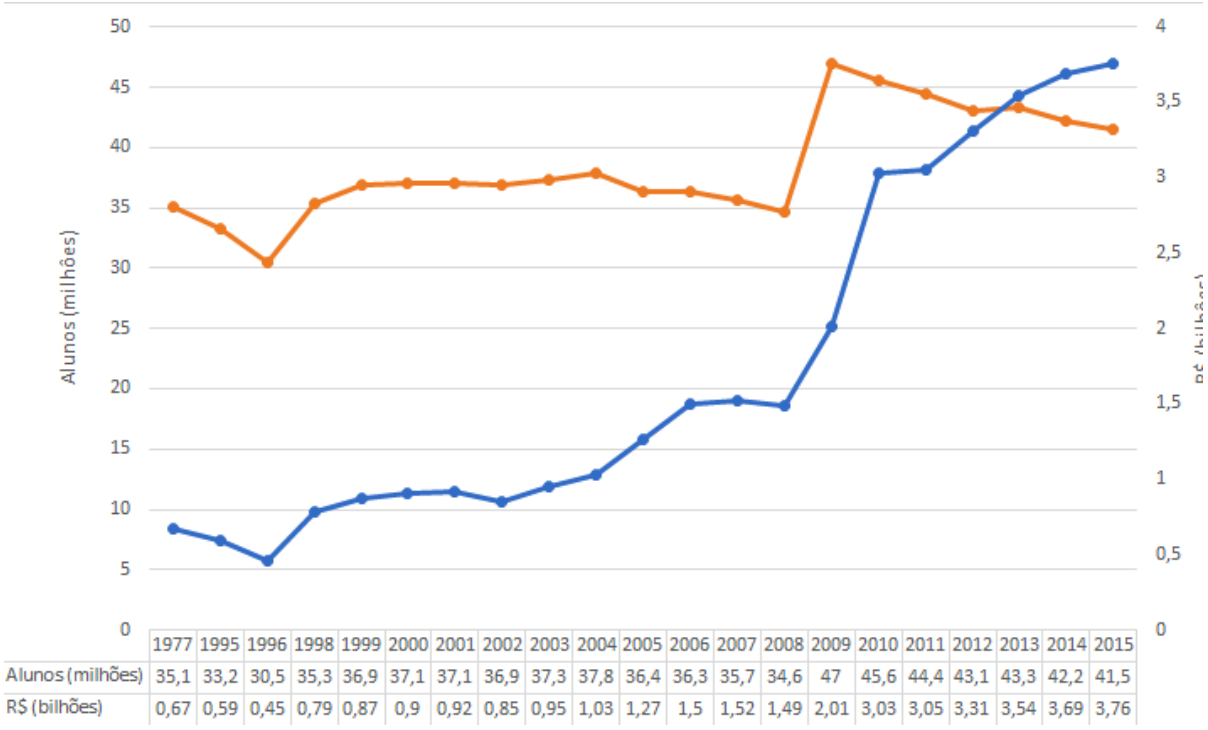
A Tabela 9 traz o número de alunos beneficiados pelos programas de alimentação escolar da região da América Latina e Caribe.

No Brasil, o PNAE é umas das políticas públicas mais antigas e mais duradouras. Apenas a Índia provê número maior de refeições em escolas, sendo o segundo maior programa de alimentação escolar do mundo em número de refeições (WFP, 2017; HGSF, 2016; Nogueira et al., 2016).

Dados históricos sobre o número de alunos atendidos e sobre investimentos financeiros são mostrados na Figura 11.

Tabela 9: Alunos beneficiados pelos programas da América Latina e Caribe (WFP, 2017)

País	Alunos beneficiados	Ano
Brasil	41.500.000	2015
México	6.357.712	2015
Colombia	4.029.869	2015
Peru	3.537.460	2015
Equador	2.873.148	2015
Guatemala	2.535.116	2015
Bolívia	2.383.408	2013
Rep Dominicana	1.739.355	2016
Chile	1.620.586	2015
Honduras	1.337.830	2015
El Salvador	1.300.000	2016
Nicaragua	1.200.000	2015
Paraguai	1.085.942	2014
Haiti	876.000	2015
Cuba	827.070	2015
Panamá	499.137	2015



	1977	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Alunos (milhões)	35,1	33,2	30,5	35,3	36,9	37,1	37,1	36,9	37,3	37,8	36,4	36,3	35,7	34,6	47	45,6	44,4	43,1	43,3	42,2	41,5
R$ (bilhões)	0,67	0,59	0,45	0,79	0,87	0,9	0,92	0,85	0,95	1,03	1,27	1,5	1,52	1,49	2,01	3,03	3,05	3,31	3,54	3,69	3,76

Figura 11: Alunos atendidos e investimentos do PNAE (FNDE, 2017a)

O PNAE tem como princípio prover alimentação durante 200 dias letivos por ano a alunos de escolas públicas federais, estaduais, municipais e distritais, creches, pré-escolas, escolas primárias, escolas secundárias, escolas para jovens e adultos, instituições de caridade, escolas ligadas a igrejas e instituições de caridade, e esco-

las comunitárias (Nogueira et al., 2016). A Tabela 10 traz os principais eventos que consolidaram o PNAE no Brasil.

Tabela 10: Cronologia do PNAE (Nogueira et al., 2016)

Ano	Evento
1955	Campanha da Merenda Escolar é instituída
1960	Provisão de refeições completas para estudantes
1979	O PNAE é instituído
1980	Descentralização da provisão de merenda pelo PNAE
1988	Promulgação da Constituição Federal torna PNAE política de Estado
2001	Regulação prevê que pelo menos 70% dos recursos transferidos pelo FNDE adquiram produtos levando em consideração hábitos regionais alimentares
2009	Lei 11947 estabelece diretrizes para alimentação escolar e conexão entre o PNAE e a agricultura familiar é regulamentada
2013	Resolução do FNDE estabelece diretrizes para refeições para o ensino fundamental por meio do PNAE e a participação da agricultura familiar é ampliada

2.3.1 *Home Grown School Feeding*

Programas de alimentação escolar que operam em número planejado de dias por ano, com alimentos pré-determinados, provendo oportunidades para a agricultura local, gerando demanda estável e previsível, são a base conceitual dos programas *Home Grown School Feeding* (Bundy, 2011; Casey & Commandeur, 2016; HGSF, 2014).

Países com economias de baixa e média renda entendem cada vez mais os programas de *Home Grown School Feeding* (HGSF) como oportunidades para melhorar os meios de subsistência dos pequenos agricultores e das comunidades locais e para fortalecer a relação entre nutrição, agricultura e proteção social (Food and Agriculture Organization of the United Nations & World Food Programme, 2018; HGSF, 2019b).

Os programas de alimentação escolar buscam objetivos educacionais, de proteção social e nutricional, ou uma combinação desses. Os programas de *Home Grown School Feeding* também geram benefícios adicionais, não só para os alunos e seus domicílios, mas também para os agricultores que fornecem os alimentos, para as comunidades locais e para outras partes interessadas (Food and Agriculture Organiza-

tion of the United Nations & World Food Programme, 2018).

A Figura 12 mostra os benefícios dos programas HGSF comparados com os programas de alimentação escolar tradicionais.

Por meio da vinculação da alimentação escolar à agricultura familiar, os programas HGSF contribuem para acelerar o progresso do objetivo sustentável 2 da Agenda 2030 adotada pelas Nações Unidas e também contribuem com os objetivos 1 na erradicação da pobreza, 4 na qualidade da educação, 5 na igualdade de gênero, 8 na melhoria das condições de trabalho e crescimento da economia, 10 na redução das desigualdades e 17 nas parcerias (ONU, 2015a; Food and Agriculture Organization of the United Nations & World Food Programme, 2018).

Quando os programas nacionais de HGSF foram estabelecidos, surgiram demandas estruturadas e previsíveis para produtos da agricultura local, mas, na prática, os pequenos agricultores não conseguiram acesso aos programas com o alcance previsto e desejado (Maijers & Nalla, 2014).

Pequenos agricultores enfrentam desafios no acesso ao mercado de alimentação escolar. Uma gama de atividades de apoio à agricultura destinadas a melhorar o fornecimento de alimentos dos pequenos agricultores tem sido utilizada no âmbito dos programas de HGSF (Tabela 11), mitigando os vários desafios encontrados (Casey & Commandeur, 2016).

Exemplos de *Home Grown School Feeding* são vistos ao redor do planeta. Em 2005, o Presidente Olusegun Obasanjo da Nigéria lançou o *Home Grown School Feeding and Health Programme* (HGSHP). O programa nacional de alimentação escolar traz na sua denominação o termo *Home Grown* contribuindo com o *Universal Basic Education Programme* do país (Agbon et al., 2012). O HGSFHP busca fornecer alimentos cultivados localmente por pequenos agricultores. Os objetivos do programa são declarados como melhorar o número de matrículas e taxas de conclusão, melhorar os níveis de nutrição e da saúde das crianças, fomentar as atividades agrícolas locais, criação de empregos e melhoria da economia familiar e estatal (NHGSFP, 2019).

Figura 12: Evolução dos programas de alimentação escolar (Bundy et al., 2018)

Tabela 11: Abordagens para mitigar os desafios dos agricultores familiares (Casey & Commandeur, 2016)

Desafios	**Identificar nichos e inteligência de mercado**	**Treinamento em negócios**	**Construção de capacitação técnica e logística**	**Acesso a serviços financeiros**
Baixo conhecimento dos requisitos alimentares da HGSF	x			
Não familiarizados com tendências e avaliação de processos do HGSF		x		
Falta de orientação para negócios, falta de staff e transparência		x	x	
Negócios informais sem certificações			x	
Baixa capacidade de armazenagem e unitização			x	
Difícil acesso a financiamento				x
Múltiplos *stakeholders* provêm apoio não coordenado	x	x	x	x

O distrito nigeriano de *Osun* conta com o programa *Osun State Elementary School Feeding and Health Programme* relançado em 2012, sendo reconhecido globalmente como referência de programas *Home Grown School Feeding* (HGSF, 2014).

O governo do Quênia implementou programa nacional de HGSF em 2009, beneficiando mais de 500 mil alunos em 1711 escolas. O Ministério da Agricultura do país atua junto aos agricultores familiares para melhorar a produção, adquirida pelo programa (Bundy, 2011).

Por meio de numerosos investidores na alimentação escolar para que "a fome não seja mais uma barreira à educação de uma criança", o programa HGSF atingiu em Mali 15,4% das escolas. A alimentação escolar tem sido focada nas áreas mais vulneráveis que sofrem de insegurança alimentar. Nessas áreas, a proporção de escolas com programas de HGSF é de 26,1%, sendo 1313 de 5047 escolas (HGSF,

2019a).

A Figura 13 mostra fatos que evidenciam a evolução do conceito de HGSF no mundo a partir do ano 2003.

Em 2009, o Brasil tornou-se o primeiro país a vincular explicitamente a agricultura por meio da lei de alimentação escolar que tornou a compra obrigatória de pequenos agricultores de pelo menos 30 por cento da quantidade total de alimentos para a alimentação escolar. Essa foi uma medida para fortalecer a agricultura familiar e incentivar a geração de renda rural e urbana, e melhorar a mobilização social. A lei n º 11 947, de 2009 exige uma abordagem local em termos de cultura e agricultura alimentar, com incentivos para a compra de alimentos diversificados produzidos localmente, preferencialmente por agricultores familiares e empresários familiares rurais (Bundy et al., 2018).

2.4 Cidade de Mogi das Cruzes

Mogi das Cruzes é o 53º município de maior população do Brasil e o 13º do Estado de São Paulo com 433.901 habitantes. Sua área é de 712,5 km² e a densidade demográfica de 609 hab/km². Seu PIB é de R$ 14,1 bilhões e seu PIB per capita é de aproximadamente R$ 33 mil (46ª posição entre os 100 maiores municípios em termos populacionais) (Macroplan, 2018).

Considerada a principal cidade na região do cinturão verde de São Paulo, Mogi das Cruzes tem grande relevância na produção de hortaliças, frutas e flores do Brasil, além da importante parcela do mercado nacional de cogumelos, caqui, nêspera, hortaliças e flores com grande presença de agricultores de origem japonesa (Santos & Bello, 2014). O legado dos imigrantes e seus descendentes inclui técnicas de agricultura, como o desenvolvimento de novas espécies de vegetais e flores e hábitos alimentares orientais (da Silva et al., 2015).

Um conjunto de indicadores da educação do município de Mogi das Cruzes (IBGE, 2019) inclui informações do Índice de Desenvolvimento da Educação Básica (IDEB), demonstrados na Tabela 12.

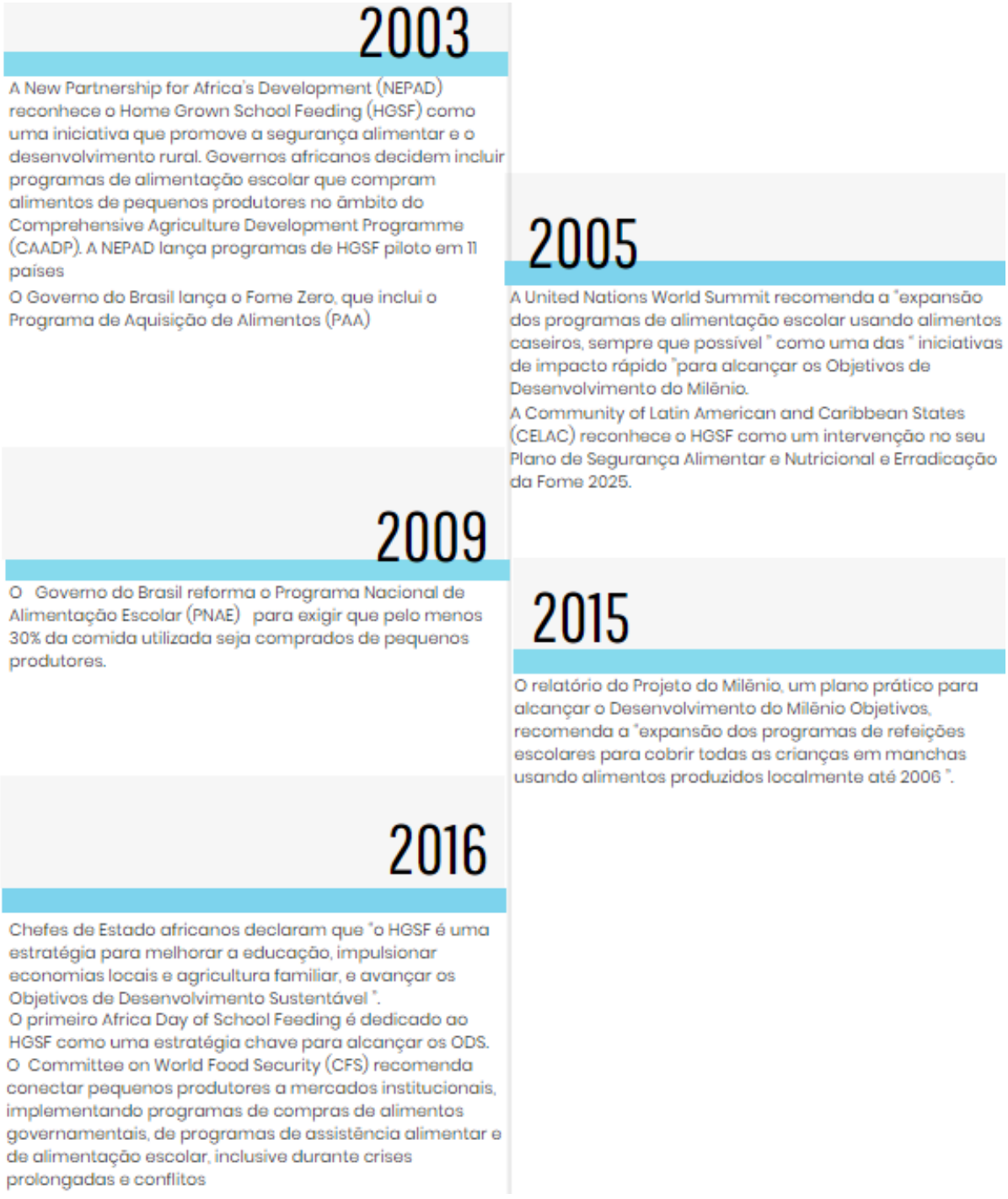


Figura 13: O surgimento e evolução do conceito de HGSF (Food and Agriculture Organization of the United Nations & World Food Programme, 2018)

Tabela 12: Indicadores da educação de Mogi das Cruzes (IBGE, 2019)

Indicadores de educação	**índices**
Taxa de escolarização de 6 a 14 anos de idade (2010)	97,70%
IDEB – Anos iniciais do ensino fundamental (2015)	6,3
IDEB – Anos finais do ensino fundamental (2015)	4,7
Matrículas no ensino fundamental (2017)	55.495
Matrículas no ensino médio (2017)	20.459
Docentes no ensino fundamental (2017)	2.824
Docentes no ensino médio (2017)	1.234
Número de estabelecimentos de ensino fundamental (2017)	189

O município é o 30º no ranking do Índice dos Desafios da Gestão Municipal (IDGM), com relevância nas áreas de segurança (9ª posição) e educação (16ª posição). O *ranking* do IDGM é construído a partir de um índice sintético reunindo indicadores nas áreas de educação, saúde, segurança e saneamento e sustentabilidade. A Tabela 13 traz indicadores da educação infantil e fundamental do município de Mogi das Cruzes (Macroplan, 2018).

Tabela 13: Indicadores de educação infantil e fundamental de Mogi das Cruzes (Macroplan, 2018)

	2007		2017	
Educação Infantil	Índice	Posição	Índice	Posição
Matrículas na creche (razão entre o total de crianças de 0 a 3 anos de idade e o nº de matrículas na creche)	16,80%	30º	42,90%	16º
Matrículas na pré-escola (razão entre o total de crianças de 4 a 5 anos de idade e o nº de matrículas na pré-escola)	100%	1º	96,80%	23º
Educação Fundamental				
IDEB Ensino Fundamental I (Rede Pública)	4,4	34º	6,3	16º
IDEB Ensino Fundamental II (Rede Pública)	3,9	20º	4,7	19º

A atividade agrícola é marcante. O número de estabelecimentos agropecuários na cidade era 1379 em 2017 (IBGE, 2019). A Figura 14 mostra que, em comparação com as cidades do Estado de São Paulo, Mogi das Cruzes é um dos líderes em números de estabelecimentos agropecuários (IBGE, 2017).

A classificação dos agricultores do município por idade e cor ou raça são demonstrados na Tabela 14.

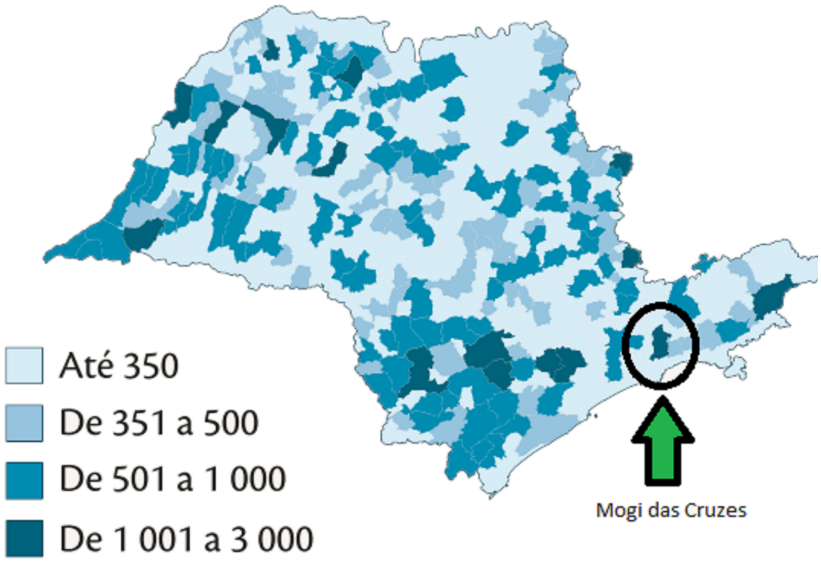


Figura 14: Cidades por número de estabelecimentos agrícolas (IBGE, 2017)

Tabela 14: Idade e raça dos agricultores de Mogi das Cruzes (IBGE, 2019)

Idade do produtor	menor que 30 anos	67
	de 30 a menos de 60 anos	824
	de 60 anos ou mais	468
Cor ou raça do produtor	branca	580
	amarela	490
	parda	239
	preta	48
	indígena	2

O número de estabelecimentos agropecuários por condição legal do produtor rural em 2017 está demonstrado na Tabela 15.

Tabela 15: Condição legal do produtor de Mogi das Cruzes (IBGE, 2019)

Condição legal do produtor	**estabelecimentos**
produtor individual	1192
condomínio, consórcio ou união de pessoas	168
sociedade anônima ou por cotas de responsabilidade limitada	9
outra condição	9
cooperativa	1

A Figura 15 mostra que em comparação com as demais cidades do Estado de São Paulo e com Brasil, Mogi das Cruzes é um dos municípios líderes em números produtores individuais agrícolas (IBGE, 2017).

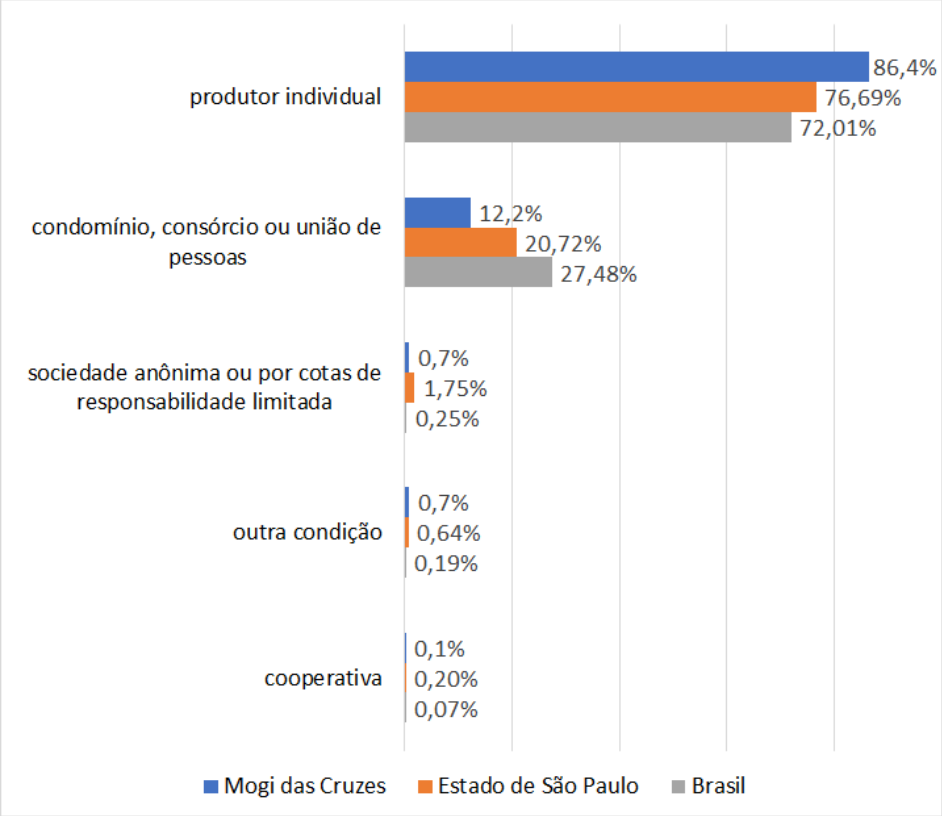


Figura 15: Comparação entre as condições legais dos agricultores (adaptado de (IBGE, 2017))

A escolaridade dos produtores rurais é fator importante para as estratégias governamentais de apoio à atividade agrícola. Os agricultores com menor grau de instrução podem recorrer à assistência técnica pública ou privada, que podem substituir ou complementar os conhecimentos desses produtores (Reis et al., 2017). O número de estabelecimentos agropecuários por nível de escolaridade dos produtores é demonstrado na Tabela 16.

Tabela 16: Escolaridade dos produtores famillíares de Mogi das Cruzes (IBGE, 2019)

escolaridade do produtor	**estabelecimentos**
nunca frequentou escola	44
classe de alfabetização – ca	31
alfabetização de jovens e adultos - aja	5
antigo primário (elementar)	244
antigo ginasial (médio 1º ciclo)	187
regular do ensino fundamental ou 1º grau	240
eja - educação de jovens e adultos e supletivo do ensino fundamental ou do 1º grau	6
antigo científico, clássico, etc. (médio 2º ciclo)	10
regular de ensino médio ou 2º grau	277
técnico de ensino médio ou do 2º grau	86
eja - educação de jovens e adultos e supletivo do ensino médio ou do 2º grau	9
superior - graduação	215
mestrado ou doutorado	5
não se aplica	20

Na comparação com os níveis de escolaridade com o estado de São Paulo e com o Brasil, nota-se que o município tem menor percentual de agricultores que nunca frequentaram a escola e maior percentual de agricultores com ensino médio completo. O percentual de agricultores com curso superior e com mestrado e doutorado está abaixo do percentual do Estado de São Paulo. A Figura 16 traz dados comparativos entre a escolaridade dos agricultores de Mogi das Cruzes, o estado de São Paulo e o Brasil (IBGE, 2017).

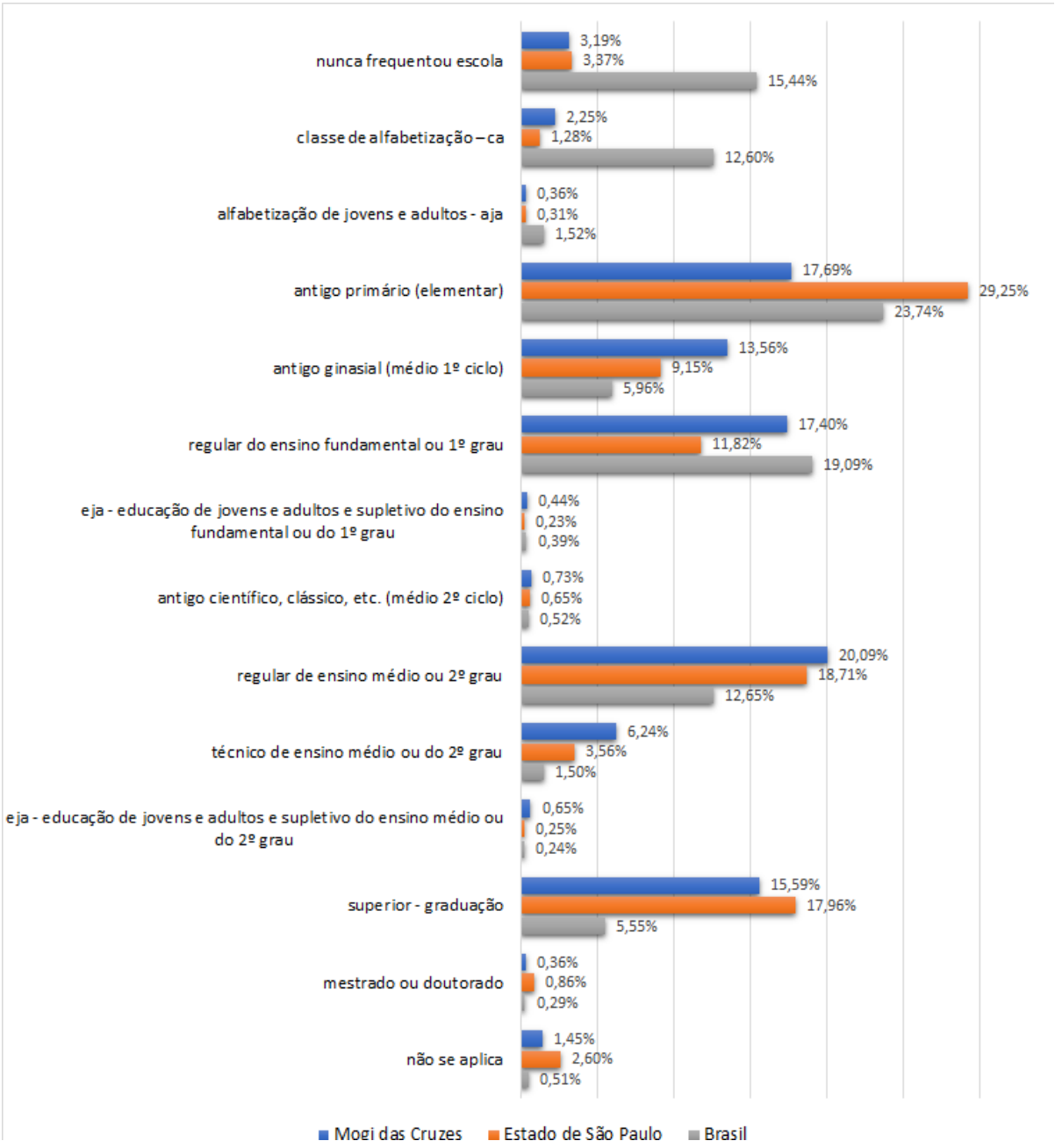


Figura 16: Comparação da escolaridade dos agricultores(IBGE, 2017)

A Tabela 17 traz o número de pessoas ocupadas em estabelecimentos agropecuários na cidade de Mogi das Cruzes em 2017, classificando por laço de parentesco.

Os dados de pessoal com laço de parentesco com o produtor demonstrado incluem os membros das famílias remunerados pela atividade da agricultura familiar no município.

Tabela 17: Pessoal ocupado em estabelecimentos agropecuários (IBGE, 2019)

PESSOAL OCUPADO EM ESTABELECIMENTOS AGROPECUÁRIOS	**5982**
COM LAÇO DE PARENTESCO COM O PRODUTOR	**3233**
Homens de menos de 14 anos	18
Homens de 14 anos e mais	2126
Mulheres de menos de 14 anos	17
Mulheres de 14 anos e mais	1072
SEM LAÇO DE PARENTESCO COM O PRODUTOR	**2749**
Permanentes	2171
Temporários	480
Parceiros	98

3 Metodologia

Este capítulo traz informações gerais sobre a metodologia adotada no estudo. Para a realização desta pesquisa, um conjunto de métodos foi adotado para cumprir fases e objetivos específicos diversos. A Figura 17 traz as fases do estudo, os métodos utilizados em cada fase, e a relação entre os métodos para a consecução dos objetivos da pesquisa.

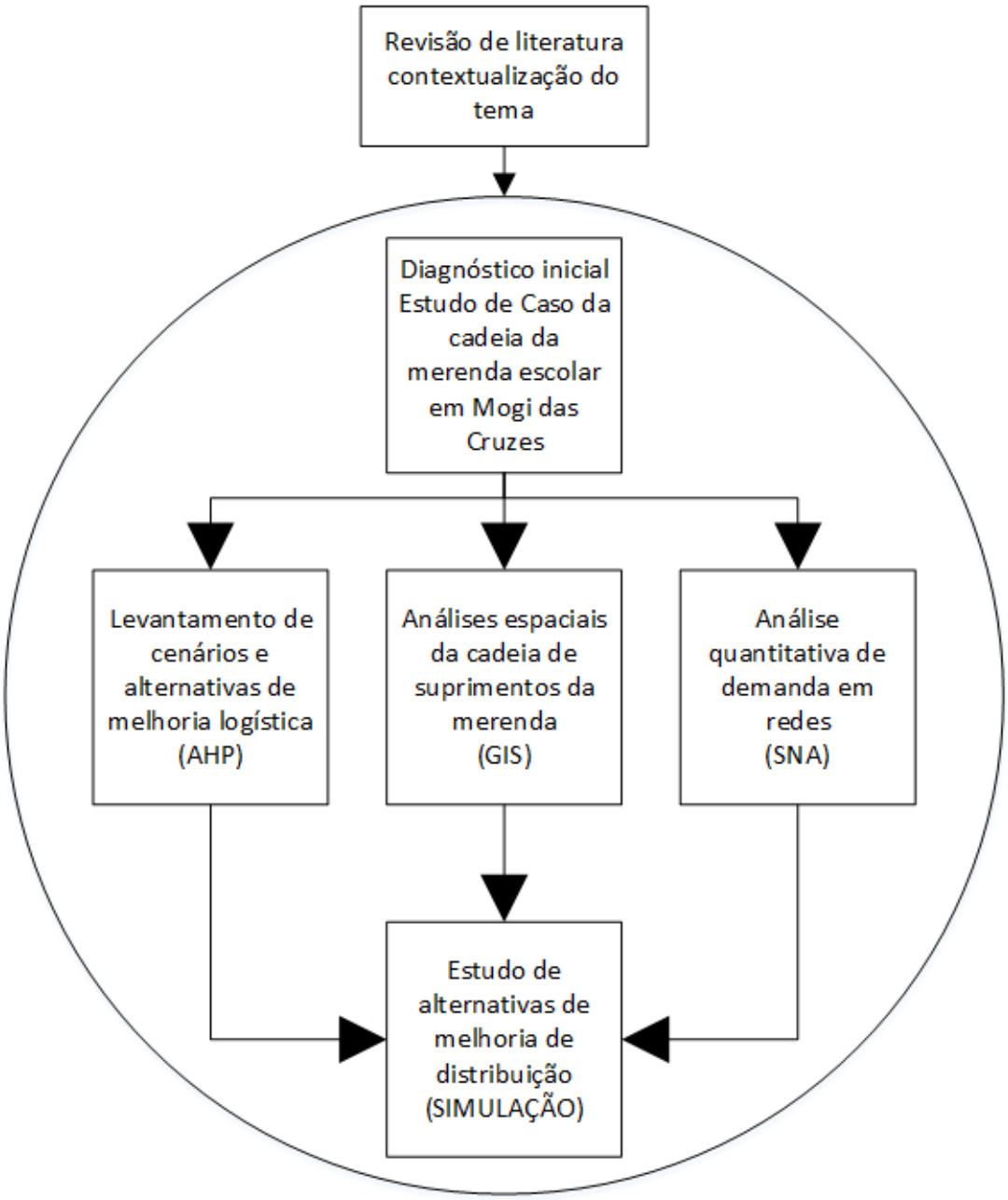


Figura 17: Relação entre os métodos utilizados

Cada fase proposta na Figura 17 foi desenvolvida e documentada por meio de

produções científicas, em artigos e um capítulo de livro. Em cada produção científica há revisão de literatura e detalhamento dos métodos utilizados nas respectivas fases.

3.1 Revisão de Literatura

Foi elaborada revisão de literatura abordando aspectos diversos sobre a agricultura familiar no Brasil e na cidade de Mogi das Cruzes, *Food Supply Chains* e *Short Food Supply Chains*, e sobre programas de alimentação escolar no mundo e o Programa Nacional de Alimentação Escolar (PNAE) e sobre os métodos adotados na pesquisa *Analitic Hierarchy Process* (AHP), *Social Analysis Network* (SNA) e Simulação de Eventos Discretos. A revisão de literatura compõe o capítulo 2 desta pesquisa, e permitiu visão ampla e contextual do tema, em âmbito mundial. Foram levantadas informações que inserem a temática na discussão global de apoio à agricultura familiar, segurança alimentar e programas de alimentação escolar implantados ao redor do mundo. Os assuntos discutidos na revisão de literatura são análogos e encontram contextualização com a agenda 2030 das Nações Unidas, em que vários dos 17 objetivos de desenvolvimento sustentável são contemplados (ONU, 2015b).

Com o objetivo de explorar o atual estado da arte do tema estudado foram efetuadas consultas em importantes bases de dados Science Direct, Emerald, Scielo e Wiley. Também foram feitas consultas intensas aos relatórios e *releases* de órgãos governamentais como IBGE - Cidades e do Fundo Nacional para o Desenvolvimento da Educação (FNDE). Consultas aos relatórios das agências da Organização das Nações Unidas (ONU) como *Food and Agricultural Organization* (FAO) e *World Food Programme* (WPF) foram realizadas. Foram consultadas publicações e relatórios de importantes organizações globais ligadas ao tema estudado, como a HGSF-Global e *Netherlands Development Organisation* (SNV).

3.2 Diagnóstico Inicial

Foram realizadas visitas e contatos frequentes com a secretaria da agricultura de Mogi das Cruzes para diagnóstico inicial, maior conhecimento da temática e maior profundidade na definição dos problemas de pesquisa. Dados foram coletados por meio de documentos e registros da secretaria da agricultura. Reuniões e entrevistas foram feitas com o secretário da agricultura e com assessores.

As pesquisas mais comuns em engenharia de produção são estudo de caso, *surveys*; modelamento e simulação; pesquisa-ação; pesquisa bibliográfica, e pesquisa experimental (Miguel, 2007). Foi utilizada a abordagem de estudo de caso para a elaboração de artigo científico, levantando-se características da produção de alimentos na cidade de Mogi das Cruzes e do papel do governo local no apoio e fomento a

agricultura familiar.

O artigo *The role of local food production to reduce food losses and improve regional economy* foi publicado em abril de 2019 na *Independent Journal of Production and Management*.

3.3 Análises espaciais da Cadeia de Suprimentos

Foram obtidos junto aos assessores da secretaria da agricultura da cidade de Mogi das Cruzes a geolocalização (arquivos em formato *.kmz) de todas as escolas da rede pública, da sede da Associação dos Produtores Rurais de Jundiapeba e Região (APROJUR), e das propriedades rurais homologadas como fornecedoras ativas do PNAE.

Sistemas de Informações Geográficas (*Geographic Information Systems* - GIS) são compostos por *software, hardware* e funções diversas, e são usados para suportar a coleta, gerenciamento, processamento, análise, modelagem e exibição de dados espaciais, para que problemas complexos de planejamento e gerenciamento possam ser resolvidos (Hu & Liu, 2017). A análise de *hotspot maps* permitem definir com clareza regiões em que esforços maiores devem ser empreendidos (Keum et al., 2018).

Foram elaborados mapas para a consecução de análises espaciais da rede formada por escolas e produtores. Os estudos analisaram as distâncias entre escolas e a sede da APROJUR. Por sugestão de membros da Secretaria da Agricultura, o Departamento de Alimentação Escolar (DAE) foi estudado como uma proposta de ser um novo ponto de distribuição dos alimentos comprados da agricultura familiar. As Figuras 18, 19 e 20 são exemplos de mapas elaborados para as análises espaciais realizadas em sistema de informações geográficas. A Figura 18 traz a localização da cidade de Mogi das Cruzes no Estado de São Paulo. A Figura 19 traz a localização das escolas, produtores, ponto de distribuição atual (APROJUR) e proposto (DAE). A Figura 20 mostra a concentração das escolas e as distâncias em relação ao DAE (métodos de *buffer* e *hot spot map*).

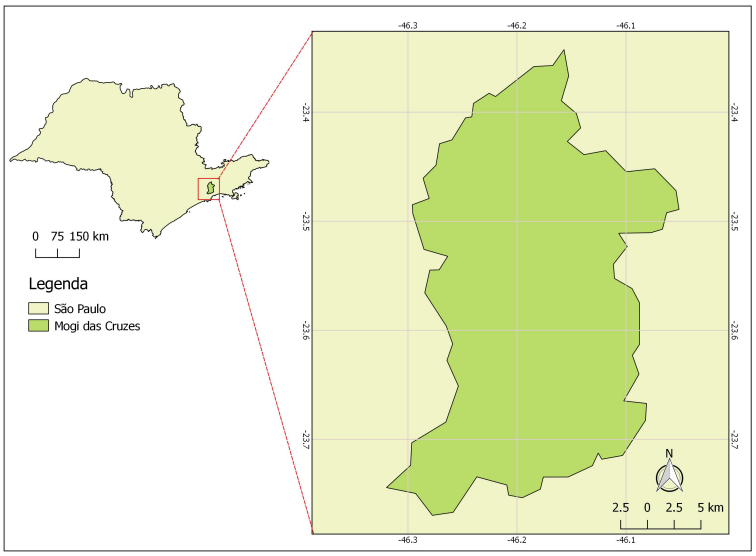


Figura 18: Mapa de Mogi das Cruzes (autor)

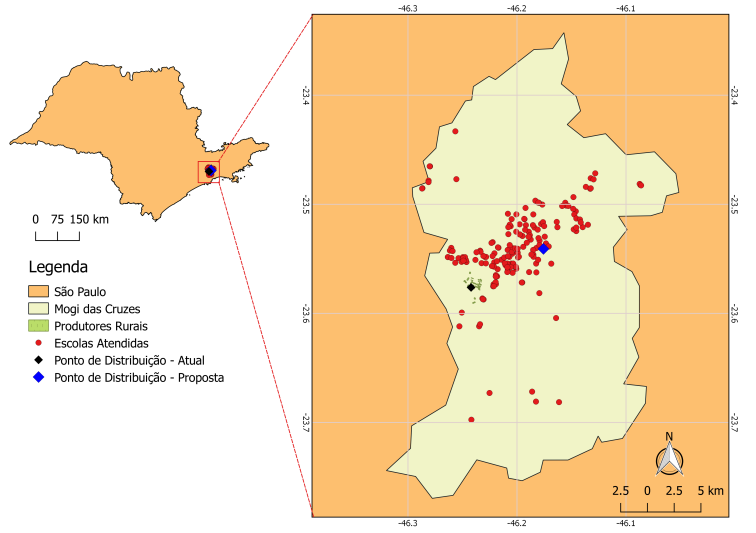


Figura 19: Escolas e produtores familiares (autor)

O artigo *Developing a system to improve food distribution in public schools: a case in Mogi das Cruzes* foi aceito para publicação, prevista até o segundo semestre de 2019 na revista *AGRARIAN*.

Um capítulo do livro *Food Supply Chains in Cities: Modern Tools for Circularity and Sustainability - Publisher: Palgrave Macmillian - Crainfield University (UK)*, com o título *Food Distribution and School Feeding: a case study in Mogi das Cruzes city, Brazil*, foi aceito para publicação, prevista para o segundo semestre de 2019.

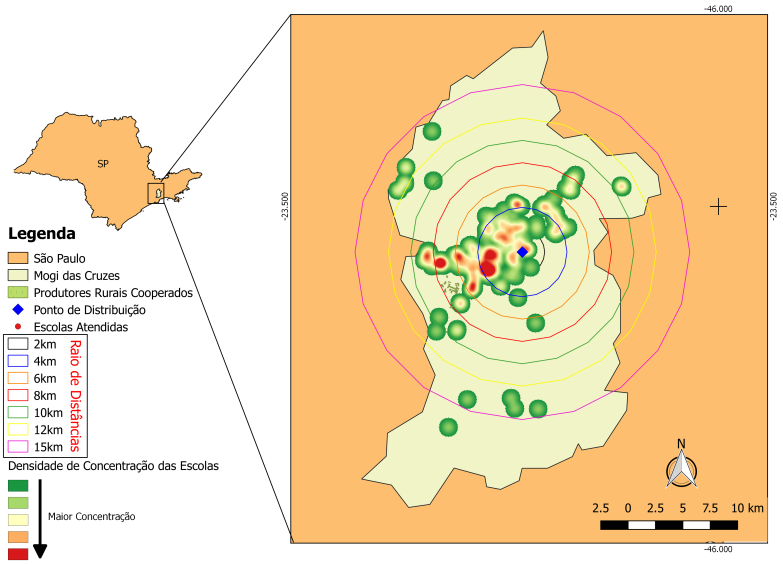


Figura 20: *Hot spot map* - concentração de escolas (autor)

3.4 *Social Analysis Network* (SNA)

Foi realizada visita ao Departamento de Alimentação Escolar (DAE), subordinado à secretaria da educação de Mogi das Cruzes. Na ocasião foi possível conhecer as instalações e atividades desempenhadas pelo departamento. Foi solicitado um conjunto de dados históricos de compra e consumo dos alimentos adquiridos da agricultura familiar com recursos do PNAE. A solicitação foi feita oficialmente conforme instruções do governo municipal. A diretora responsável pelo DAE obteve autorização da secretaria da educação do município para a disponibilização de dados do exercício de 2017 (anexo I - resposta da secretaria da educação da solicitação de informações para estudo de fluxos).

Social Analysis Network (SNA) representa uma metodologia interdisciplinar para mapeamento e medição de relacionamentos e fluxos entre pessoas, grupos e organizações (Milovanović et al., 2019). Aplicações da metodologia SNA permitem a identificação de relações diretas do desempenho de redes em muitas áreas diferentes (de Marcos et al., 2016).

Um dos elementos-chave que caracteriza a análise atual de redes sociais são visualizações de redes complexas. Comparando-se com listas ou tabelas, analisar uma estrutura de rede pode fornecer visão mais ampla, detectando-se grupos, *clusters*, comunidades e participantes principais (Hansen et al., 2011).

Uma gama de redes sociais foram elaboradas utilizando os *softwares* UCINet e Netdraw, buscando-se estudar relações entre alimentos e escolas, alimentos e cooperativas, e relações entre cooperativas, alimentos e escolas. Foram utilizadas métricas importantes de SNA como *betweenness* e *centrality degree*. O artigo produzido traz

detalhes sobre as métricas e as redes principais do estudo.

O artigo *Food Distribution for Primary Schools in Brazil: An Analysis of Product Flows in a Short Supply Chain* será submetido após o fechamento da tese para revista qualificada nos extratos Qualis A1 e A2 e primeiro percentil scopus.

3.5 *Analitic Hierarchy Process* (AHP)

A consistência dos sistemas de apoio à decisão depende amplamente da qualidade da árvore de decisão subjacente. Quando várias opções e variáveis têm de ser consideradas em uma decisão, é muito importante determinar as prioridades de forma precisa dentro do método AHP (Suner et al., 2012). O estudo baseado no método multicritério de decisão *Analitic Hierarchy Process* (AHP) se iniciou pela elaboração da árvore de decisão e posterior validação junto ao secretario da agricultura e assessores da secretaria, juntamente com especialistas. O objetivo global do estudo, conforme consta na Figura da árvore de decisão, foi avaliar os fatores de maior impacto na operação logística do PNAE em Mogi das Cruzes.

Após a validação da árvore foi elaborado o questionário (Apêndice B) para coleta dos julgamentos dos atores principais da rede.

A coleta dos julgamentos dos produtores e das escolas da rede foram realizadas em dois eventos promovidos pelo governo local.

Os agricultores familiares responderam os questionários em um evento promovido pela secretaria da agricultura em que foram abordadas questões de boas práticas da atividade agrícola. O evento ocorreu na sede da APROJUR, local em que os alimentos são entregues pelos produtores e a operação de *cross-docking* é realizada, antes da distribuição para as escolas. Todos os agricultores ativos no PNAE responderam o questionário (Apêndice C)

As escolas da rede pública foram representadas em um evento promovido pela secretaria da educação e responsáveis pela merenda escolar. O evento foi planejado e ministrado pelo Departamento de Alimentação Escolar (DAE). Todas as escolas da rede que recebem alimentos da agricultura familiar responderam o questionário (Apêndice C)

A árvore de decisão definida pelo estudo é mostrada na Figura 21. Os julgamentos foram tratados no software *Expert Choice*. Foram realizados estudos dos produtores, das escolas, e todos os respondentes em conjunto. Os fatores julgados como de maior impacto na operação logística do PNAE foram avaliados por grupos, sendo escolas, produtores e especialistas. Também foi realizada a análise consolidada dos três grupos de respondentes.

O artigo *Understanding Challenges in Food Distribution for School Feeding Programmes: family farming outlook in Mogi Das Cruzes city, Brazil* está em revisão final

e será submetido para periódico qualificado *Nature Scientific Reports*.

3.6 Simulação de Eventos Discretos

Um estudo baseado em simulação foi elaborado para estudar o sistema de distribuição dos alimentos adquiridos da agricultura familiar com origem na sede da APROJUR e com destinos às 209 escolas da rede pública.

A simulação foi adotada devido a algumas razões. A variável "tempo de transporte"é considerada crítica pelos atores da SFSC. Como o tempo se comporta probabilisticamente, modelos de otimização baseados em programação linear não seriam suficientes, pois estudam sistemas determinísticos, em que os coeficientes das variáveis de decisão dos modelos são invariáveis. As técnicas de otimização são adequadas para minimizar distâncias por exemplo. A variável "distância"também foi analisada, mas externamente ao modelo de simulação.

Outra razão para a adoção da simulação é a possibilidade do uso dos recursos de animação para maior entendimento do comportamento do sistema de distribuição pelos atores envolvidos. A animação dos modelos de simulação tem sido um recurso valioso para o entendimento de profissionais que atuam em áreas diferentes da engenharia ou tecnológica.

A principal alternativa testada a partir dos resultados do método AHP é a mudança do ponto de distribuição para o DAE. Atualmente o principal ponto de atividades de intralogística é a sede da APROJUR, localizada em área próxima aos produtores familiares assentados e ativos no PNAE. A partir da sede da APROJUR ocorre a distribuição diretamente para as escolas da rede.

O cenário testado previu a mudança do ponto de distribuição a partir das instalações do DAE, como foi previsto nos problemas da pesquisa, com base em sugestão dos membros da secretaria da agricultura.

As análises espaciais realizadas por meio de Sistemas de Informações Geográficas (GIS) embasaram o estudo de simulação para testar novas rotas. A análise visual dos mapas elaborados se constituíram no ponto inicial da simulação, para que novos grupos de escolas sejam atendidos pelas atuais oito rotas. Também foi avaliado cenário alterando-se o número de rotas.

O fluxograma do modelo de simulação foi documentado e parametrizado no simulador ARENA (Figura 22).

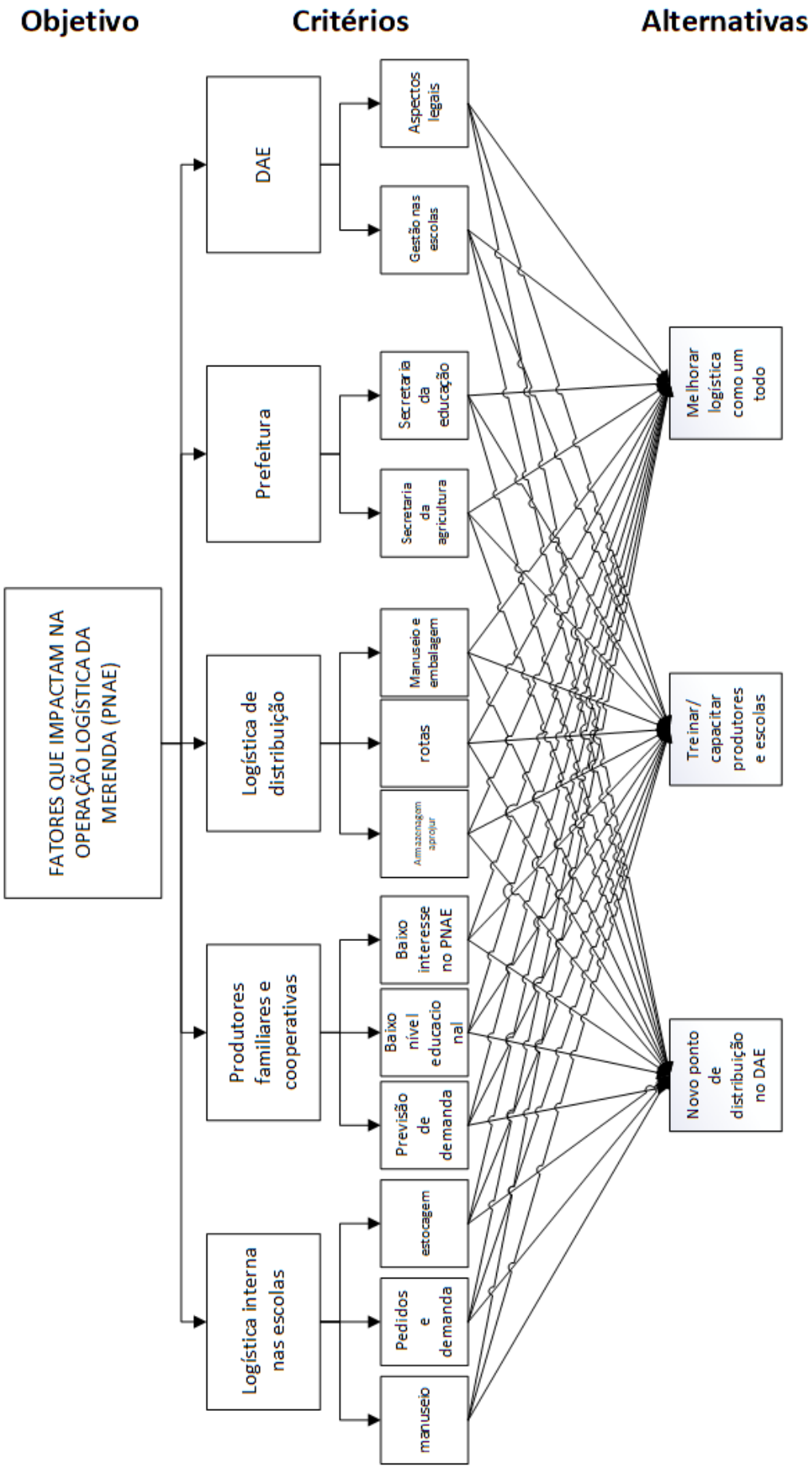


Figura 21: Árvore de decisão (autor)

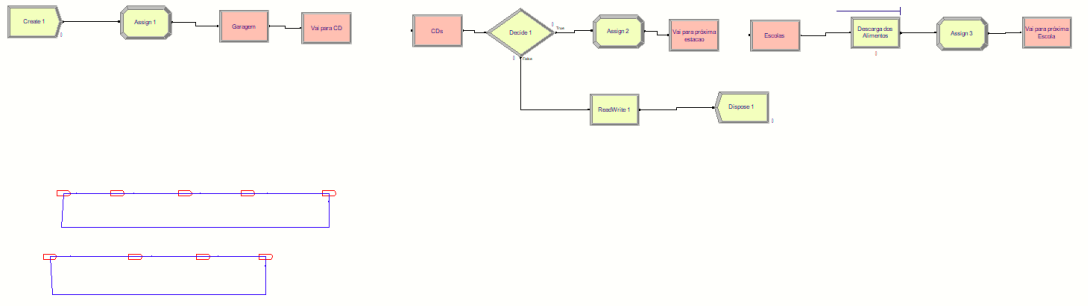


Figura 22: Modelo de Simulação elaborado no ARENA

Os critérios de modelagem permitem que o modelo elaborado avalie cenários em que SFSC opere com refeições padronizadas, procurando-se aumentar a escala do PNAE, baseando-se no estudo de redes que utilizou o método SNA. Outras análises de padrões de demanda dos alimentos adquiridos da agricultura familiar podem ser realizadas sem novos esforços de modelagem. O modelo permite a criação de novas rotas, inserção ou diminuição de veículos, e mudanças nos pontos de distribuição por meio de alteração de parâmetros dos módulos logícos e de dados do software Arena.

Com a finalização do estudo de simulação, foram concluídas todas as fases da presente pesquisa previstas na Figura 17.

4 Resultados e discussão

4.1 Artigo I

Título do artigo: *The role of local food production to reduce food losses and improve regional economy*

Publicação em abril de 2019 na *Independent Journal of Production and Management*.

Esse artigo foi o passo inicial da presente pesquisa, porque permitiu ampliar a visão acerca da temática e identificar as fases subsequentes.

O papel do governo municipal foi um dos principais focos desse diagnóstico inicial e dentro da construção da contextualização do assunto e dos limites da tese, o PNAE se mostrou como uma das ações mais importantes e complexas dentre as atribuições das Secretarias da Educação e da Agricultura.

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THE ROLE OF LOCAL FOOD PRODUCTION TO REDUCE FOOD LOSSES AND IMPROVE REGIONAL ECONOMY

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ABSTRACT

Brazil is one of the most important agricultural producers worldwide. However, the nation faces logistics and distribution matters due to the size of the country. Therefore, local food producers are fundamental to Food Supply Chains performance. They are near to the consumers and reduce the logistics impacts. To understand the role of local food producers, this study analyzes the Local Food Production in Mogi das Cruzes and the support of the local government. The city is the hub of Sao Paulo's metropolitan green belt. We collected data directly from the Municipal Secretariat of Agriculture. The results suggest that the local government performs technical and legal actions and there is a concerning in supporting the local food producers, keep on this economic activity in a good level of efficiency.

Keywords: Local Food Production; Green Belt; Mogi das Cruzes city

1. INTRODUCTION

Brazil is one of the most important countries in agribusiness of the world. An estimation of 2017 for the Brazilian harvest of cereals, vegetables and oleaginous totaled 221,400,000 tons, 20.3% higher than 2016 when the production reached 184 million tons. The estimated harvested area is 59,900,000 hectares in 2017, that represents an increase of 4.9% compared to 2016, with 57,100,000 hectares.

Rice, corn and soybeans are examples of very important products of this group, which, together, accounted for 93.5% of total estimated production and 87.4% of the harvested area. Compared to the previous year, there is an increase of 1.9% in soybeans, 10.3% in corn and 1.2% in rice. About production, there was an increase of 11.8% for soybeans, 10% for rice and 38.9% for corn (IBGE, 2017).

From a supply chain perspective, the globalization in the agribusiness sector has influenced Food Supply Chains (FSC) that are affected by increasing the distance between food production and the consumers. This situation not only has enlarged emissions of greenhouse gases but also has decreased the relationship between local food producers and consumers (BOSONA; GEBRESENBET, 2011).

Another fundamental factor relies on the fact that distance raises the food losses along the supply chains. The Food and Agriculture Organization of United Nations (FAO) estimates that one-third of all food produced globally for human consumption is lost during the stages of production and transport or wasted after the food purchasing, during the stages of cooking, sorting, and consumption (FAO, 2013).

Indeed, packing, storage, inventory management and transportation can be very challenging for FSC. There is often significant time pressure on post-harvest activities as most agricultural products are perishable. Hence, a postponement in transport may cause high losses (BEHZADI, et al., 2018).

Currently, one of the solutions analyzed to reduce these losses in the logistics process is increase the participation of Local Food Producers. There is a global movement in the sense of offers conditions for local producers who attends this

demand. In Brazil is not different and many municipalities are developing assistance programs to these producers that involve investments and buy products.

Mogi das Cruzes, for instance, considered the most important city in the green belt of the metropolitan region of São Paulo, produce and supply several types of food and flowers beside employed a huge workforce. Despite the importance of the city production some questions need to be answered as for how does the local government supports and manage the local food production? how does the local government monitor the activities of local production and how does the local food is sold nearby with the support of the local government?

This paper aims to investigate the local food production in the Mogi das Cruzes city, and to bring a wide range of information about the local government activities to help and support local food producers. This knowledge could be used to find solutions to improve production in distribution in the city and at the same time contribute with benchmarking information for other cities in Brazil and the World

The paper is divided as follows: a literature review, methods, results and discussion and finally, it presents the conclusions and suggestions for future studies.

2. LOCAL FOOD PRODUCTION

The literature discusses concepts of Local Food Production (LFP) often. It is difficult to draw conclusions about the local economic impact of local foods systems. Many studies perform narrow geographic and market scope. It is challenging to make comparisons establishing operational, logistics and government support aspects. Micro-scale business concepts have become more common around the world, and there is increasing interest in these among consumers (MIGLIORE et al., 2015). Consumers are in pursuit of different sources of food produced near their home (MIGLIORE et al., 2014; NIE; ZEPEDA, 2011).

Short Food Supply Chains (SFSC) allow understanding how and where food is produced, enabling the development of a trust relationship between consumers and producers. The main methods that could help researchers to achieve certainty are implemented to SFSCs in face-to-face relations with consumers and connecting products to their regional features (AGGESTAM et al., 2017).

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SFSCs are more accessible to producers who speak the same language as their consumers and who share similar social, economic and environmental values (JAROSZ, 2011).

The term local food slips effortlessly of the tongue and while an everyday common-sense approach might suggest that local food is produced and consumed within a scarcely well-defined geographical area, there appears to be no generally agreed or widely adopted definition.

One set of definitions is essentially based on geography and looks to define local regarding the distance between producers and customers, though there is not clear agreement of a limiting distance, or in terms of local authority boundaries. Thus, one of the definitions of local recognized by the National Association of Farmers' Markets (NAFM) is in terms of the radius from the market and while the association suggests that 30 miles is ideal, and 50 miles is however acceptable (JONES et al., 2004).

While the term "local" food is usually seen, there are no criteria. When asked to use political borders, customers generally define the term as food grown within a county or neighboring place, or within a certain city or state. Furthermore, political boundaries do not appear to be the best delineation to define local food.

Scaling food production is a world challenge. Encouraging the involvement of mid-sized farms looks to be a classic solution because it can expand the accessibility of local food while providing alternative revenue streams for troubled family farms. Many barriers stand in the way of such a development. The logistical, structural and regulatory barriers to increased scale in local food systems are well known. Limited understanding about the way in which scale developments affect the perception and legitimacy of local food systems can be a relevant matter (MOUNT, 2017).

Many familiar that defend the local food production might suggest that important pieces of added value within local food systems are generated by the reconnection of producer and consumer, the direct exchange through which this occurs, and the shared goals and values that provide the basis for reconnection (Mount, 2017).

The necessary data to measure the economic local impact are highly costly to obtain, and researchers must agree on a standard way of accounting for the costs

involved of produced and purchased local foods or on a standard set of economic modeling assumptions. Many questions surrounding the economic impact of local foods remain unanswered and could be raised by future researches, e.g., if local food systems help the city-rural economy or if the economic benefits of expanding local food systems might be unevenly distributed (USDA ERS, 2017).

According to the 2001 census in Brazil, in 1991, 233,000 people lived in rural areas of Sao Paulo city and in 2,000 that number reached 620,000 inhabitants. It suggests an interesting gap regarding the definitions of what is considered rural and what is considered urban population. This movement has happened mainly in peripheral areas, occupied by informal settlements and irregular land subdivisions which means this urban population is occupying a rural area, that has lost this main characteristic. Urban population is expanding the boundaries, in areas which are still considered rural by policies and laws (BARBIZAN, 2011).

2.1. The Importance of The Green Belt of São Paulo And Mogi Das Cruzes City

Until the middle of the 20th century, Brazilians were not aware of the wide variety of vegetables before the arrival of Japanese immigrants, characteristically diet from the sea and plants. These immigrants had a key role in Brazilian agriculture, bringing new species of vegetables and food in general. Many Japanese immigrants live in the Alto Tietê region and they have dedicated their entire lives to agriculture. The arrival of these immigrants was established through an immigration agreement between Japan and Brazil at the beginning of the 20th century (INSTITUTO FLORESTAL, 2013).

Mogi das Cruzes is considered as the main town in the region of Sao Paulo's green belt, and it has the largest center of production of vegetables, fruits and flowers of Brazil, with a relevant share of the national market of mushrooms, persimmon, loquats, vegetables, and flowers. There are a large presence of farmers with Japanese origin (SANTOS; BELLO, 2014).

Among the legacies left by immigrants and their descendants, there are many techniques of agriculture, as the development of new species of vegetables and flowers, including orchids and various foreign dishes (DA SILVA et al., 2015).

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Mogi das Cruzes city is the main food supplier of the Metropolitan region of São Paulo. São Paulo city is the biggest city in Brazil and one of the biggest cities in the world. This region is the largest pole of national wealth. The Gross Domestic Product (GDP) corresponds to about 57% of the total of the state of São Paulo. The cities that belong to metropolitan region of São Paulo are Arujá, Barueri, Biritiba-Mirim, Caieiras, Cajamar, Carapicuíba, Cotia, Diadema, Embu das Artes, Embu-Guaçu, Ferraz de Vasconcelos, Francisco Morato, Franco da Rocha, Guararema, Guarulhos, Itapevi, Itapecerica da Serra, Itaquaquecetuba, Jandira, Juquitiba, Mairiporã, Mauá, Mogi das Cruzes, Osasco, Pirapora do Bom Jesus, Poá, Ribeirão Pires, Rio Grande da Serra, Salesopolis, Santa Isabel, Santana de Parnaíba, Santo André, São Bernardo do Campo, São Caetano do Sul, São Lourenço da Serra, São Paulo, Suzano, Taboão da Serra e Vargem Grande Paulista.

A study demonstrated the importance of the green belt of Sao Paulo to preserve the environment, watershed protection areas, and water production. It was concluded, however, that it is difficult in adopting laws on the environment, low management capacity of producers, and obstacles in obtaining financing (QUEIROZ, 2013).

One of the reasons that prompted the declaration of the green belt of São Paulo as a biosphere reserve, it is due to the fact it surrounds one of the planet's largest cities that concentrates 10% of the Brazilian population, with very low rates of green area per inhabitant. The green belt brings a quality of life to the metropolis of Sao Paulo, supplying water and a variety of food. Rivers cut through the urban area, and this region is a habitat of great biodiversity of species, protects the soil from heavy rainfall, and ensures food safety of cities of the metropolitan area (INSTITUTO FLORESTAL, 2013).

The vegetables that are produced in the east region of the green belt, not only in Mogi das Cruzes but also in cities as Suzano, Biritiba-Mirim, and Salesópolis, occurs through a direct transaction with the small local retail or selling the central supermarkets supply chains. In case of sale to supermarket chains, the producer is responsible for the cost of shipping and other fees required by the company, however, it has a regular demand (SATO et al., 2006).

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3. RESEARCH METHODOLOGY

As described in the introduction, the purpose of the study is to generate an overview of the Local Food Production. We adopted a case-study approach to allow a deeper insight into the features of LFP. A case study as a research strategy often emerges as a reasonable option for students and other new researchers who are seeking to undertake a minor scale research project based on their workplace or the comparison of a limited number of organizations.

Case studies are widely accepted because they may offer insights that might not be achieved with other approaches. Finally, case studies have often been seen as a useful tool for the preliminary, exploratory stage of a research project, as a basis for the development of the framework and the methods that are required for surveys and investigations (ROWLEY, 2002).

To investigate LFP, Mogi das Cruzes city was chosen for two purposes: for its significance in São Paulo urban area where the city is in charge to produce and to distribute the main portion of vegetables and also, due to the engagement of Secretary of Agriculture of the city with LFP and its aim to share the data to develop studies that can contribute to improving the delivery of produced food in the city.

This study was conducted through interviews with the team of the Secretary of Agriculture and professionals of this division. To identify general aspects of the food production in Mogi das Cruzes, they were asked to turn information available about the role of the government of the city in managing and supporting the local food production. In addition, they were asked to demonstrate studies, researchers and developed statistics by the local government in the past years. A documental research was also conducted including data such as food production, sales, employment, and the range of performed activities by the local government.

4. RESULTS AND DISCUSSION

Sao Paulo is one of the largest cities in the world. The estimated population is 12,106,920 people, and the human development index is 0.805 (IBGE, 2017). Different foods types consumed in Sao Paulo are produced in the green belt of the city. The most influential city of the green belt is Mogi das Cruzes. The city is far 60 km from São Paulo city. Figure 1 shows the location of Mogi das Cruzes in the metropolitan region of Sao Paulo.

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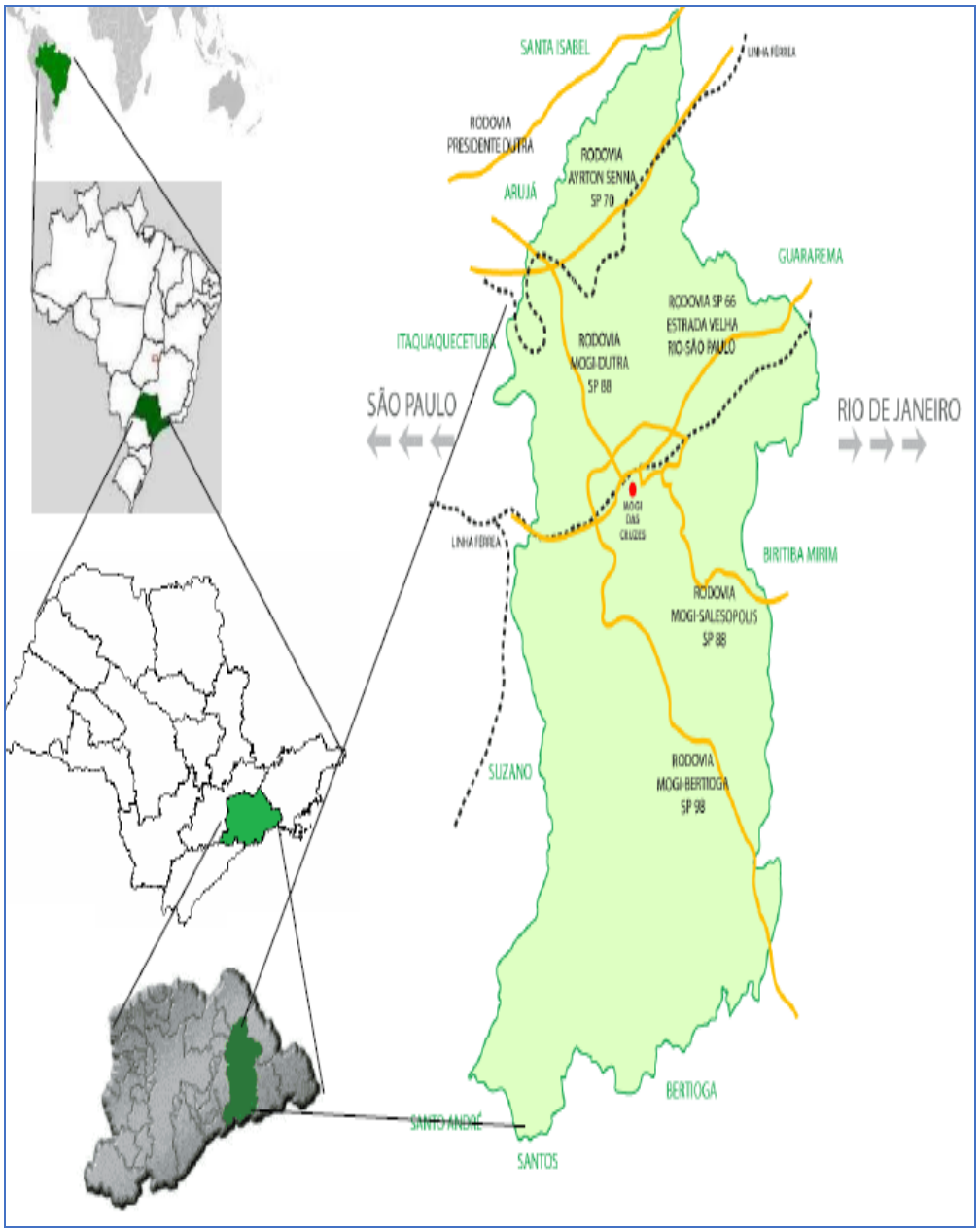

Figure 1: Location of Mogi das Cruzes city

The city of Mogi das Cruzes produces a wide range and different types of food such as fruits, vegetables, mushrooms, quail and ostrich eggs, rabbit meat and goat meat. The flowers production is considered a substantial activity in the city as well. Figure 2 provides the main products of the city for territory.

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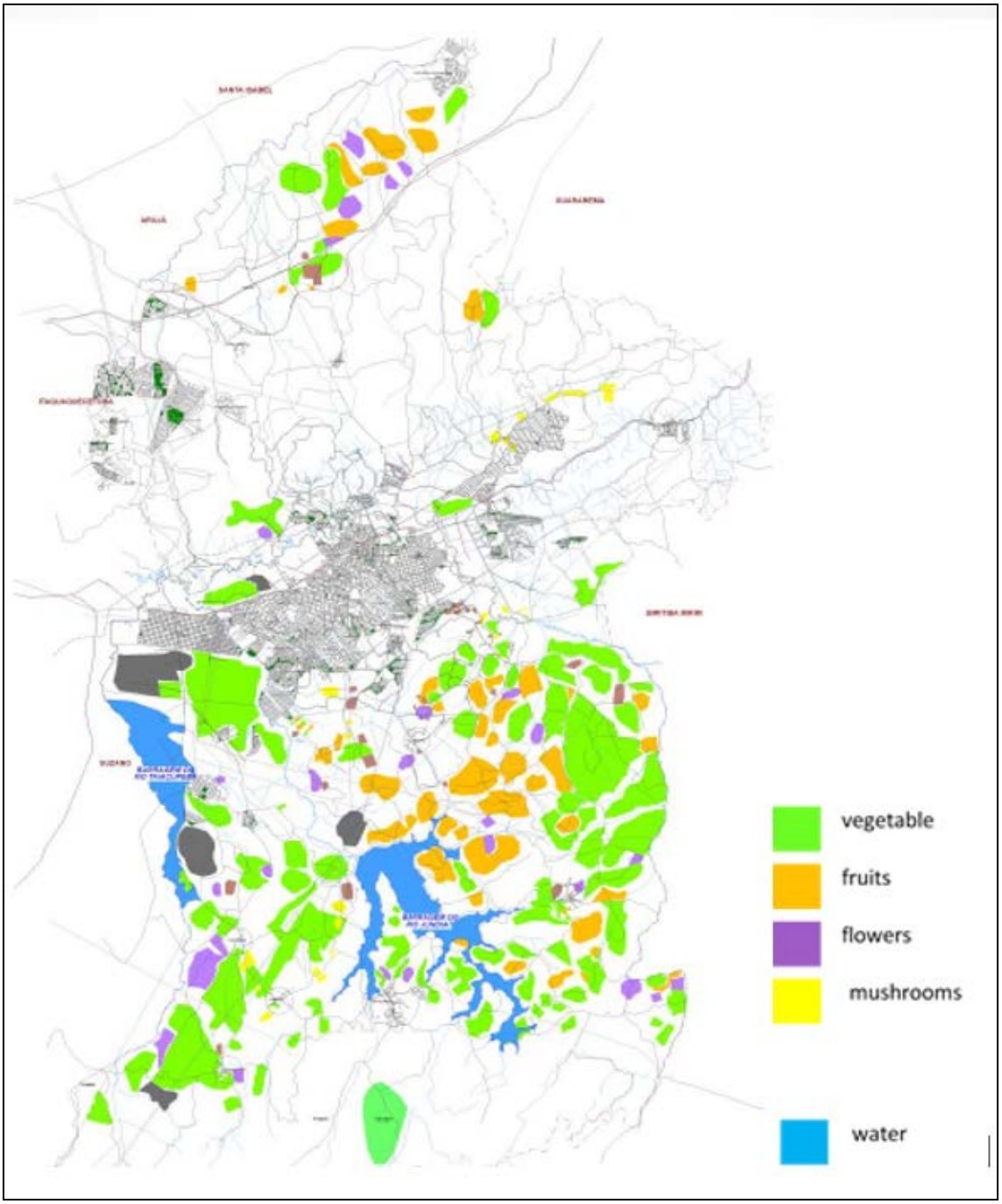

Figure 2: Areas of food production (Authors, 2018)

The monitoring and supporting of the local food production by the local government is a duty of the Secretary of Agriculture. It was founded in 2012, with the investment of BRL 974,000. The team is composed of 15 professionals that perform a wide of public activities, as can be seen in Figure 3.

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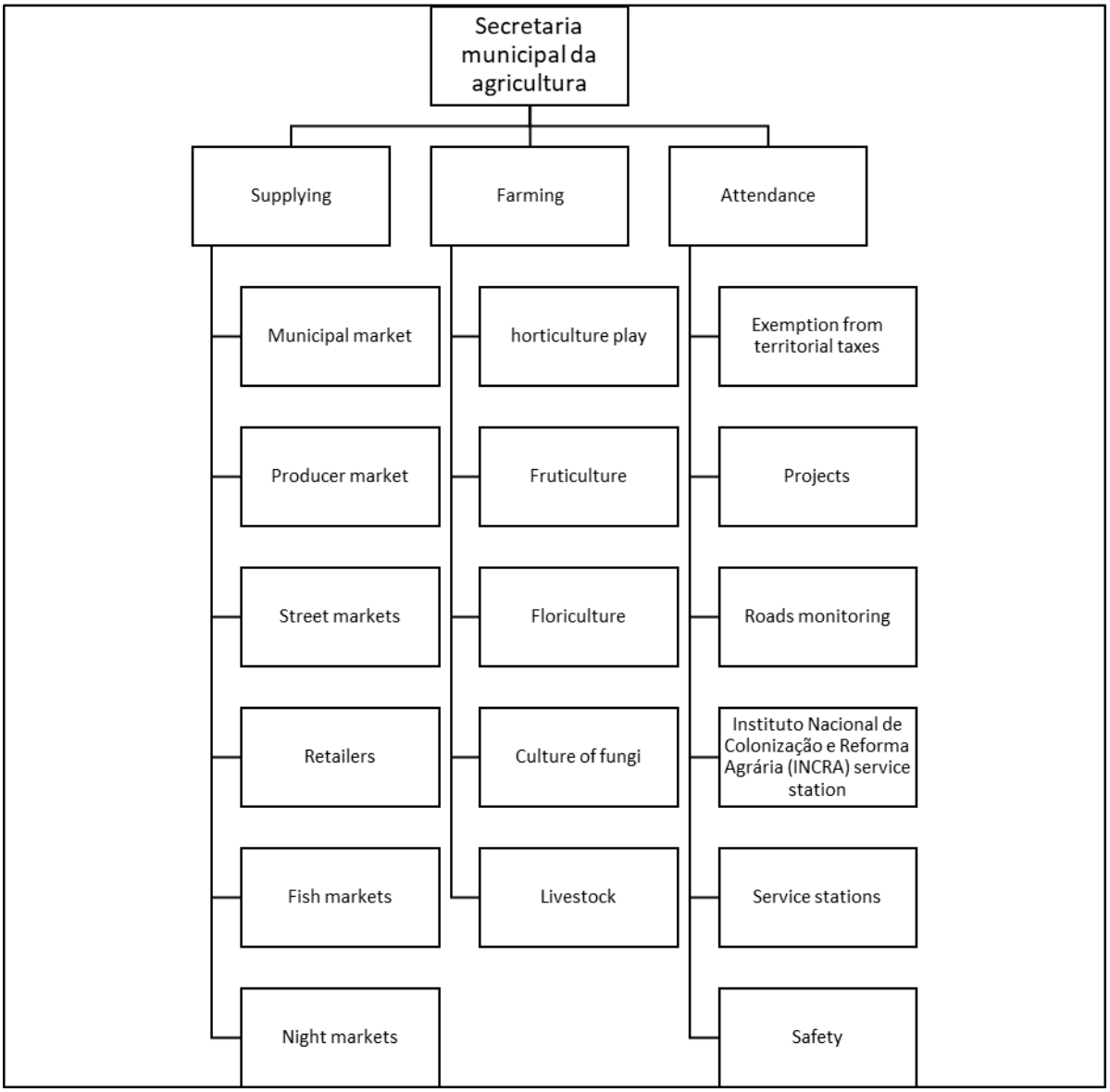

Figure 3: Activities of Secretary of Agriculture (authors, 2018)

In Figure 3 there are three subsectors that perform a wide range of activities. The first subsector (Supplying) takes care of the sales channels supported or managed by the government. There is two main sales point maintained by the Mogi das Cruzes public administration.

The local government supports the Municipal market and the Producer market where food producers sell their goods, paying a rent for the government. The local government manages the street markets, retailers, fish markets and night markets. The local producers have a license to sell the food production paying fees for the government of the city.

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The municipal market is located in a rich area of the city. Its daily activities occur in a building of 2,000 square meters. The building has 113 stores that generate approximately 1,000 jobs, considering the direct and the not direct employees. The flow of people is around 3,500 per day. The annual sales are approximately BRL 60,000,000.00.

The producer market is established in an area where local producers can sell products in trailers, shops, and stands, just on Sundays. This business generates around 2,000 employees and the sales are approximately BRL 100,000,000.00 per year. Other minor markets and retailers generate about 1,200 employees and their sales are approximately BRL 40,000,000.00 per year.

Table 1: Supplying of local food (Source: authors, 2018)

Segment	Selling locals	Employees	Anual Sales (BRL)
Municipal market	113	478	60,000,000.00
Producer market	232	928	100,000,000.00
Street markets and retailers	460	1185	40,000,000.00
Total	805	2591	200,000,000.00

The second subsector is farming. The main objective of this subsector is supporting local producers and stimulating de food production. Moreover, intents to simplify the technical support to the local producers. The subsector is divided into these following categories:

- Horticulture play: lettuce and similar vegetables, parsley, chive and similar vegetables, bulbs and tubers as potato, sweet potato, carrot, turnip, cassava, garlic, onion, beetroot, cucumber
- Fruits: Khaki (rama forte, giombo, and fuyu types), medlar (fukuhara and mizuho types), atemoya (thompson and generic types), lemon, grape, banana, nectarine, avocado, pear, lychee, passion fruit, peach, tangerine, guava and plum
- Floriculture: flower in vases, cut flowers, ornamental plants
- The culture of fungi: edible mushrooms (champignon, shitake, white shimeji, black shimeji, pleurotus, portobello, mushroom of the sun, eryngui, nameko, and enoki
- Livestock: cattle for meat production, cattle for milk production, beekeeping, aviculture, posture poultry, goats, sheep, quail culture and fish farmingMogi das Cruzes has approximately 1.8 million animal calves. It is considered the

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largest producer of orchids and hydrangeas of Brazil and it concentrates 60% of producers of mushrooms of the country. Table 2 shows data about production and sales.

Table 2: Farming production and sales (Source: authors, 2018)

Segment	Production	Unit	Sales per year
Horticulture play	560	1000 tons	BRL 450,000,000.00
Fruits	31	1000 tons	BRL 60,000,000.00
Flowers	12	millions of vases	BRL 100,000,000.00
Fungi	4,7	1000 tons	BRL 22,000,000.00
Livestock	1,8	millions of animals	BRL 90,000,000.00
			BRL 722,000,000.00

Attendance is the third subsector. Improving unpaved roads and exemption of taxes have been achieved by this subsector.

The unpaved roads are severely damaged by the traffic mainly in rainy periods. Local producers consider it is necessary a continuous improvement to decrease the food losses through the transport. During the current year, the local government or commercial partners improved 76 km of roads. The expenses were BRL 3,618,000.00.

The Exemption Program of Property Tax Territorial Urban, collected as a Rural Territorial Tax, guaranteed by municipal law, benefits the agricultural activity in areas considered as urban zones. The requests amount of the benefit is shown in Figure 4.

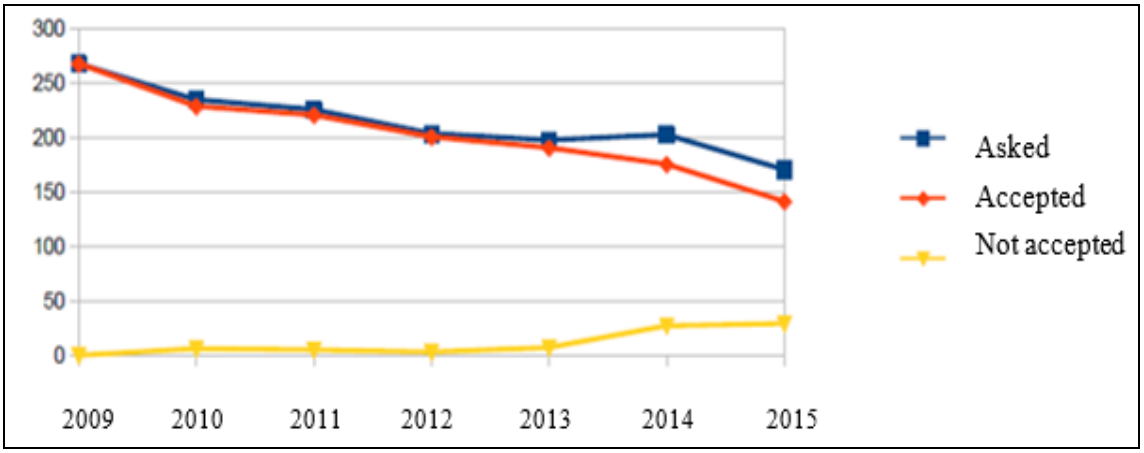

Figure 4: Requests of the exemption program

A range of other activities performed by the attendance subsector as listed below:

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- Instituto Nacional de Colonização e Reforma Agrária (INCRA) station, where the food producers can obtain licenses need for their activities (about 180 attendances by year)
- Rural safety meetings – food producers can present their safety proposals to the local police
- Public lights – lamps are installed in critical places in the rural zone, like schools, bus stations, and street crossroads
- Proposal and monitoring of projects as:
- PNAE – Programa Nacional de Alimentação Escolar (74.900 kg of vegetables purchased by local producers in 2016)
- PAA – Purchasing of the food program
- Crop launching (support for producers to calculate and sales prospecting)
- Including local food in the school's children meals, like mushrooms, vegetables, and fruits
- CAR – Cadastro Ambiental Rural – a partnership with The Nature Conservancy.
- Rural producer market
- New partnerships for roads maintenance
- Mercado Municipal safety program (safety types of equipment)
- Supplying natural gas by pipeline instead of gas cylinders

4.1. Future Projects of The Local Government

During the interviews, it was possible to identify information about the planning of local government of Mogi das Cruzes city for the next years. There is a program called Mogi 2040, where specialists, teachers, researchers, and government members work for finding new possibilities of supporting the local food producers. The main actions planned for the next 30 years are creating a Center of Educational Development, Scientific and Technological of Agribusinesses, creating a sector of Familiar agriculture business and production, marketing agribusiness program, agro production certification, farmer certification, higher efficiency of the

maintenance of roads process, agro-tourism program, familiar activities program and legal land property program.

The potential of the city of Mogi das Cruzes in consolidating itself as the main food producer city in the metropolitan region of Sao Paulo is based on different factors. The city has a privileged strategic location, close to the city of Sao Paulo, Guarulhos airport, the port of Santos and Dutra highway that links the two largest cities in Brazil, Sao Paulo and Rio de Janeiro.

The natural beauty of the region is also considered as a differential factor because it can attract tourists and help in attracting Government and private investments. The biggest challenges for the city of Mogi das Cruzes for keeping your role in food production in the coming years are the lack of training and qualification of the workforce, the lack of professionals, the preparation of the infrastructure, the family succession of properties and water scarcity.

5. CONCLUSIONS AND OUTLOOK

According to the presented literature review, Mogi das Cruzes is considered as the main town in the region of Sao Paulo's green belt, and it has the largest center of production of vegetables, fruits and flowers of Brazil, with a relevant share of the national market of mushrooms, persimmon, loquats, vegetables, and flowers.

In this study, the main purpose was to explore information of many aspects about local food production using as a case study the city of Mogi das Cruzes, considered as the most important city of the green belt of Sao Paulo, due to its wide range of food types raised in an area that is near of the biggest and the most important metropolitan area of Brazil.

It was asked how the local government supports and manage the local food production, how the local government monitors the activities of local production and how the local food is sold nearby with the support of the local government. The findings of this study suggest that the local government performs technical and legal actions and there is a concerning in supporting the local food producers, keep on this economic activity in a good level of efficiency and diversity.

The team that is in charge in the Secretariat of Agriculture accomplishes an assortment of actions, taking care of supplying and local sales issues, farming

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requests. They keep a department for attending and helping food producers in a wide of subjects as taxes, roads maintenance, and licenses.

The city of Mogi das Cruzes says that there is no sufficient official data to support the strategic management of the Secretariat of Agriculture. Surveys are expensive and slow to be performed. Data collection from the producers, landowners, and occupiers of settlements, which are often poor people with low educational qualifications, are obtained with a lot of resistance and distrust, which turn the researches very complex. In addition, failures of launched programs by previous local governments keep the producers away and cause unknown and underutilization of the departments services.

The present study should prove to be particularly valuable to raise more ideas about on how the food production is supported in Mogi das Cruzes city and why this region is so important for the food supplying for the biggest metropolitan area of Brazil. New researches that allow bringing more knowledge about the provided services by the City Council and the problems faced by local food producers, especially on land grown by family farmers, are vital to reducing the stresses and difficulties of communication.

The local government can help local family producers with training programs. The Secretariat of Agriculture has in its staff, specialized technicians whom can tutor producers on legal issues, productivity, quality, logistical operations including inbound and outbound. Training can improve the dialogue between local authorities and producers to a close, reducing eventual underutilization of the offered services by the local government.

The scope of this study was limited to the information available in the prefecture of the Mogi das Cruzes. It was stated by the team of the local government that there are no official data about the local food production of Mogi das Cruzes enough to support all the strategic planning, and to generate these data through specialized companies of research is expensive.

Further research should be undertaken to investigate the results of the investments and actions from a producer point of view and the local community in general. The small quantity of data did not allow to know what are the difficulties that

producers have in logistics, labor, funding, purchasing of fertilizer, seeds and equipment and the various factors of production.

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4.2 Artigo II

Título do artigo: *Developing a system to improve food distribution in public schools: a case in Mogi das Cruzes*

Artigo aceito para publicação prevista até o segundo semestre de 2019 na revista *AGRARIAN*.

Nesse artigo, a abordagem se baseou no objetivo específico de se mapear a cadeia de suprimentos da alimentação escolar na cidade de Mogi das Cruzes. A percepção inicial de que havia dificuldades de se encontrar indicadores adequados aos interesses dos atores da SFSC demandou o entendimento mais aprofundado da rede de distribuição.

Para cumprir essa demanda, foram adotados métodos de georreferenciamento. As escolas foram georreferenciadas. Também foram apontados nos mapas as sedes da APROJUR e do DAE e também a localização dos produtores familiares ativos no PNAE.

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Título e Resumo

Título	Developing a system to improve food distribution in public schools: a case in Mogi das Cruzes
Resumo	School feeding programs are present in different countries. These programs promote healthy food by purchasing food directly from local food producers, based on familiar agriculture. This paper studied a food supply chain of the school feeding in Mogi das Cruzes city, one of the most important food producer cities in Brazil. The local producers supply food for schools through the National School Food Program (PNAE). Data were available by the secretaria da agricultura. Using the locations of the schools and food producers, a spatial analysis of the supply network was conducted in a geographic information system. At last, it was possible to conclude that a new distribution point can bring relevant improvements to the logistics operation.

Indexação

Área e sub-área do Conhecimento	Engenharia de Produção, logística
Palavras-chave	logistics, PNAE, school feeding
Idioma	en

Developing a system to improve food distribution in public schools: a case in Mogi das Cruzes

Desenvolvimento de sistema de melhoria de distribuição de merenda: estudo de caso em Mogi das Cruzes

Resumo: Programas de alimentação escolar estão presentes em diferentes países. Estes programas promovem alimentação saudável por meio de compras feitas diretamente de produtores locais de alimentos, baseados em agricultura familiar. Este artigo estudou a cadeia de suprimentos da merenda escolar na cidade de Mogi das Cruzes, uma das mais importantes cidades produtoras de alimentos do Brasil. Os produtores locais fornecem alimentos para as escolas, por meio do programa nacional de alimentação escolar (PNAE). Dados foram disponibilizados pela secretaria da agricultura. A partir das informações das localizações das escolas e dos produtores de alimentos, análise espacial da rede de escolas foi conduzida em um sistema de informações geográficas. Finalmente, foi possível concluir que um novo ponto de distribuição pode trazer ao sistemas melhorias relevantes na operação logística.

Palavras-chave: logística, merenda, PNAE

Abstract: School feeding programs are present in different countries. These programs promote healthy food by purchasing food directly from local food producers, based on familiar agriculture. This paper studied a food supply chain of the school feeding in Mogi das Cruzes city, one of the most important food producer cities in Brazil. The local producers supply food for schools through the National School Food Program (PNAE). Data were availabled by the secretaria da agricultura. Using the locations of the schools and food producers, a spatial analysis of the supply network was conducted in a geographic information system. At last it was possible to conclude that a new distribution point can bring relevant improvements to the logistics operation.

Key words: logistics, PNAE, school feeding

1. Introduction

School feeding programs are a continuing concern to the cities around the world. School-meals provide a protective effect against food insecurity that is known to negatively impact on educational attainment via its influence on learning or school engagement (HARVEY, 2016). Researchers have shown an increased interest in school feeding and the food security during childhood (BELIK; FORNAZIER, 2017; KRISTJANSSON et al., 2016; LÓPEZ-OLMEDO et al., 2018). They can also enhance lifelong health and wellbeing. Effective interventions to improve child nutrition can ensure healthy lives and promote well-being. However, to realize these goals, decision makers need to be able to identify which of these

interventions are effective and why, so they also need evidence on their costs, cost per outcome and cost-effectiveness (KRISTJANSSON et al., 2016).

These subjects are related to important matters as food security in childhood, food losses and wastes, using of public resources, and different aspects of Food Supply Chains management. However, one of the main obstacles for a good performance of school feeding programs is the transport. The mayoralty purchases directly from farming organizations, including those originating from land reform programs and family farmers. From the farmers' side, the new opportunities opened by school meals program procurement disclosed their fragile organization regarding delivery logistics and quality patterns of food provided (BELIK; FORNAZIER, 2017).

In Brazil offers food in schools is an obligation of municipalities that receiving federal investment to provide it. As the country is a continent with crucial social differences, the challenge is higher. In Brazil there are 5570 municipalities (IBGE 2017). In this study we choose Mogi das Cruzes due its importance as a food producer city. The purpose of this study is not offer a solution to all the cities because depend of specific characteristics but is to provide a case study that could motivate the cities in developing similar researches.

Mogi das Cruzes city is considered a very important food producer city in Brazil. There are about 3,000 food producers in the city. Using resources of the Programa Nacional de Alimentação Escolar (PNAE – National Program of School Feeding), the municipal government buys food from 58 local producers that supply for 209 schools located at the city´s area.

Logistics problems are noticed. Costs of transport are expensive. Even so, the transportation company claims constantly for higher prices. The producers take the food to a distribution point that is far from the most of schools. The delivery is made to schools and so quality control is tough. Schools suffer from receiving and storing. Problems are highlighted because the food is bought with public resources.

Questions can be raised. Is it possible to improve the operation changing the local of the distribution point? What changes could be implemented to help schools in its logistics issues?

This paper attempts to analyze the school feeding programs and food supply chains that involves schools and food producers in Mogi das Cruzes and proposing a new distribution point aiming for improvements in distribution. Particularly the study will focus in vegetables supply chains. Also, an objective of this study is to propose changes in the operation to help schools in its logistics issues.

The first section of this paper will bring literature review about school feeding programs and studies that investigate distribution and logistics operations. After we describe the method and the results of the investigation. Finally, we conclude that a new distribution point can improve the logistic operation of the Food Supply Chain.

2. Background

2.1 School feeding programs

There is a growing body of literature that recognizes the importance of the food supply chains and the school feeding programs (CHAUHAN, 2015; SOARES et al., 2017a; TORRES; BENN, 2017). Also, more recent attention has focused on the food security, food losses and wastes, and the food supply chains (BILSKA et al., 2016; LEBERSORGER; SCHNEIDER, 2014).

Food security is a major concern in large parts of the developing world. Food production must clearly increase significantly to meet the future demands of an increasing and more affluent world population. In developing countries, school feeding is a key factor for food security during childhood.

But, overweight and obesity in children have become a worldwide public health problem. This matter is posing a major challenge. The health and economic consequences are huge, especially when occurring at an early age. Between 42.5 and 51.8 million children aged 0–19 years are obese in Latin America. It is approximately 20–25% of the population. The World Health Organization (WHO) recommends interventions to prevent overweight and obesity. A substantive change can be achieved involving coordinated efforts including schools. .

School feeding programs are widespread. Global estimates show that approximately 370 million children received school feeding in 2012 (KRISTJANSSON et al., 2016).

A study conducted in Jamaica, examined the attendance patterns by region of schools which participated in School Feeding Programs in poor, remote rural areas and determined whether there was a significant difference in attendance over a 10-year period between children who took different lunch types (JENNINGS, 2016).

The globalization has affected the food supply chains. There has been an expansion of a model of agriculture based on monocultures of food on a large scale. This model has harmed on the small and medium-sized producers, contributing to the exodus and rural poverty. Countries must define their agricultural policies and ensure food supply through local production. Policies that encourage the market of local food from the direct buy of consumer have arisen from this perspective. School feeding programs, present in different countries, promote healthy feeding through direct purchase and sustainable food systems from local farmers. United States, Ghana, Indonesia, Brazil, El Salvador, Honduras, Nicaragua, Paraguay, Niger, Senegal, Ethiopia, Mozambique, and Malawi have incorporated these policies in school feeding programs (SOARES et al., 2017b).

The earliest institutional responses to the problem of hunger and malnutrition in Brazil took place in the early 1940s with the creation of the Serviço de Alimentaçao da Previdencia Social (SAPS - Social Security Food Service), and the only school feeding initiatives existing in Brazil were administered by UNICEF, which, during the 1950s, began to deliver skimmed milk to 350,000 school children in eight states. The national government took its first action in 1955, when following the launch of the First National Plan for Food and Nutrition, a public-school food program was established. In this phase of developmentalism (1945 -1964), in which industrialization and economic modernization were the main priorities for the federal government in

Brazil, the goal was to centralize the school food system by connecting the existing regional initiatives to supply packed meals to school children with international food aid circuits (SONNINO; LOZANO TORRES; SCHNEIDER, 2014).

The federal Brazilian government encourages a proper nutrition in public schools and the purchase of locally produced foods in small rural properties. The Programa Nacional de Alimentação Escolar (PNAE - National School Feeding Program) provides food and nutritional education of all stages of basic education. The federal government transfers for public schools, financial values as an additional sum in 10 monthly instalments (from February to November) to cover 200 school days, as the number of students enrolled in each school network. The law 11947 guarantees that 30% of the transferred value by the PNAE must be invested in direct buy of familiar agriculture products. The law stimulates economic development and sustainable communities (FNDE, 2018).

The Programa Nacional de Alimentação Escolar (PNAE - National School Feeding Program) provides free meals to over 40 million students. When it began in the 1950 's, the program had the goal of addressing undernourishment. The current diet of most Brazilians is of low nutritional quality. The daily intake of vegetables and fruits is low. The intake of unhealthy foods is high. The increase in overweight among children ages 5 to 9, has become a new challenge of the program (SOARES et al., 2017b).

Many poor children that live in urban and rural areas depend on the school meals to prevent starving. Funds from PNAE buys food from familiar local farmers located in the city of Mogi das Cruzes. The food feeds students of public schools maintained by the municipal government.The PNAE is the oldest social program of Federal, State and Municipal Governments in education area. It has as main goal of supplying the nutritional needs to reduce dropout rates. The city of Mogi das Cruzes handles about 80% of the financial resources. The Federal Government send about 30% of the financial resources for buying food from local producers. In 1994, Law 8913 transferred to municipal governments the responsibility of organizing daily menus, purchasing the ingredients, performing quality control and monitoring the use of resources through the operation of the Conselhos de Alimentaçao Escolar (CAEs - School Nutrition Councils), which were designed to enhance civil society participation in school food policies (SONNINO; LOZANO TORRES; SCHNEIDER, 2014).

2.2 Transporting food

Food Supply Chain (FSC) management has been attracting increasing attention from the academics and the practitioners. Much effort has been made to improve the living standard. Though, problems such as high chain cost, food waste, food losses and environmental matters still occur (LI et al., 2016).

The management of the distribution of perishable products, like food, needs the perpetual control of the environmental conditions of storage and transport facilities in order to avoid those stresses that may affect their shelf life and quality. Lots of perishable goods are wasted because of inefficiencies during the subsequent transport process. The amount of wastage could be reduced via better planning and control of transport activities (LIN; NEGENBORN; LODEWIJKS, 2016).

The perishable food products distribution can be abstracted as vehicle routing problem. It has long been

recognized that managing perishable food is a difficult problem, such as vegetables, milk, meat and flowers distribution (WANG et al., 2016).

Many types of food are highly perishable and fragile. The added value is low and therefore the transport must be efficient with the lowest possible cost. Cross-docking is increasingly used to reduce inventory holding and the time products spend in the supply chain. It is especially suitable for fresh produce distribution with a short shelf-life (AGUSTINA; LEE; PIPLANI, 2014).

Relevant strategic decisions such as the location of facilities are of great importance during the design of the supply chain and its distribution network given the perishable nature of fresh food. However, the subject has not been treated much in the literature, especially due to the difficulty of its modeling (ORJUELA-CASTRO; SANABRIA-CORONADO; PERALTA-LOZANO, 2017).

A study has revised operational research models to solve decision problems related to fresh Food Supply Chains. Problems of transport, routing, involving the production and distribution stages attracted attention (SOTO-SILVA et al., 2016). This study showed that hub location problems are a field of interest of interdisciplinary researchers.

Another study showed the importance of hubs locations for the distribution of food supplied by local producers. The authors designed a logistic network that eases access through efficient connections between production and consumption sites (ETEMADNIA et al., 2015).

Public School Food Procurements are recognized as drivers of food and nutrition security (FILIPPINI et al., 2018). It is relevant studies that improve the logistics of the school feeding programs, due its social impacts.

3. Methods

The main purpose of this article is to analyze the distribution of food in schools in Mogi das Cruzes, Brazil and investigate how an adoption of a transit point could improve this logistics operation. The city of Mogi das Cruzes was chosen to this study due to the geographic area that difficult the access of vehicles to schools, and the interesting of the mayor in improving the system.

After an extensive literature review, we seek to identify the current distribution procedure, verifying the issue and fails in this system. To this step, we used the QGis 2.18 software. This software performed a geospatial analysis in a geographic information system that allows interpreted the existing situation. We adopted the buffer method, aiming to verify the reaching radius of the new distribution point and the hot spot mapping using Kernel density estimation to identify the schools' concentration.

Buffer method can be used to determine an area of influence in relation to the object of interest. Buffers can be built around any kind of vector geographic object: points, lines, or polygons (BARBOSA et al., 2015). In this study, the buffer represents a circle whose radius is the distance between suppliers and the schools.

The heat map is a method of estimation of density curves. Each point is weighted by distance from a central value. It is possible to determine the pattern of a phenomenon or process analyzed, allowing an overview on the map (SANTOS et al., 2009). This method could be applied to, for instance, finding 'hot spots' of traffic accidents, street crimes or leakages in gas and oil pipe lines (OKABE; SATOH; SUGIHARA, 2009). In this study, the heat map or Kernel density method identified the concentration of schools.

The combination of buffer and kernal methods was frequently used (BARBOSA et al., 2015).

For the delimitation of the city of Mogi das Cruzes in São Paulo state, a vector shapefile format file was used, conforming to a digital range of Brazilian cities, available on the website of Instituto Brasileiro de Geografia e Estatística (IBGE - Brazilian Institute of Geography and Statistics).

4. Results and Discussion

Mogi das Cruzes is regarded as the most important city of the green belt of the metropolitan region of São Paulo and stands out for the strong presence of family farmers. The city is in the Southeast region of the State of São Paulo in Brazil and has 713.3 km ² and its population is 387,241 inhabitants. The population density is of 542.9 inhabitants per km ². The city lies about 746 meters of altitude, latitude: 23° 31 's ' 29 ' ' South, longitude: 46° 11 ' 14 " West ("Município de Mogi das Cruzes, São Paulo" 2017). The Figure 1 shows the location of the city.

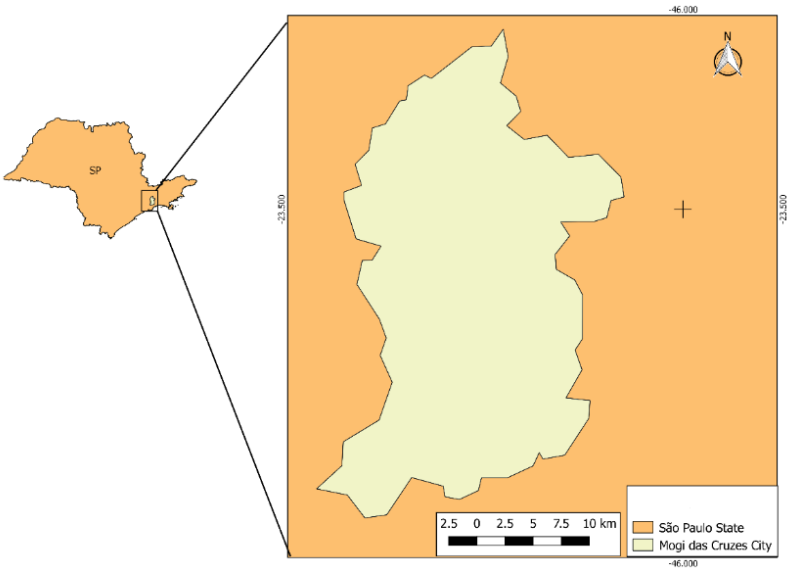

FIGURE 1 – MOGI DAS CRUZES CITY. SOURCE: ADAPTED FROM QGIS V. 2.18

The local government needs supply food in a network with 209 schools. ,Regular food such as rice, beans, sugar are standardized and bought from the regular suppliers. Products such as chard, lettuce, chives, cauliflower, cabbage, endive, escarole, parsley, beetroot, carrot, chayote, and zucchini, need to be provide by family farm producers located in the city boundaries.

The Brazilian law number 11.947 determines that 30% of products used in the lunch preparation is obliging to buy of familiar agriculture (FNDE, 2018). To motivate the enforcement of law by the municipalities, the Federal Government create the Programa Nacional de Alimentação Escolar (PNAE - National School Feeding Program) for offering federal resources to cities buy products of these families. In Brazil 84,36% of agriculture production is composed by the familiar agriculture ("Censo Agro 2016", 2006).

As mentioned, Mogi das Cruzes is in a green belt of vegetable producers, therefore the mayor develops a

cooperative of 58 local food producers that are in a settlement at the neighborhood in the rural area of the city. These producers provide vegetables to local government distribute them in schools.

The local producers send the food to a shed of a producer's association, where two cooperatives members receive, handle, pack, and board the food into 8 urban vehicles with 1,785 kg capacity each, and external dimensions of 5,085 mm of length, 1,740 mm of width and 1,965 mm height. A transport company is hired by the government that pays by kilogram transported and kilometer units.

4.1 Logistics issues

The products are sent to the schools with no processing activity, as cutting and repacking in this distribution point. Therefore, the logistics operation shows problems such as a high shipping cost, difficulty in controlling the quality of food supplied and low predictability of delivery schedules. Additional problem is that the limitation of resources in schools like handling and storage equipment are not considered by the producers, because the foods are delivered fresh without any processing such as cutting and packaging in smaller units, that could be suitable for storing and freezing. Big sizes and weights do not fit in schools' refrigerators and the handling is difficult because it is done by women.

One of the most important logistics issues is the location of the current distribution point. The storage area is far from most schools and the quality of the roads is poor. Many of them are not paved providing an extra challenge to the distribution. The Figure 2 presents the map of point of distribution.

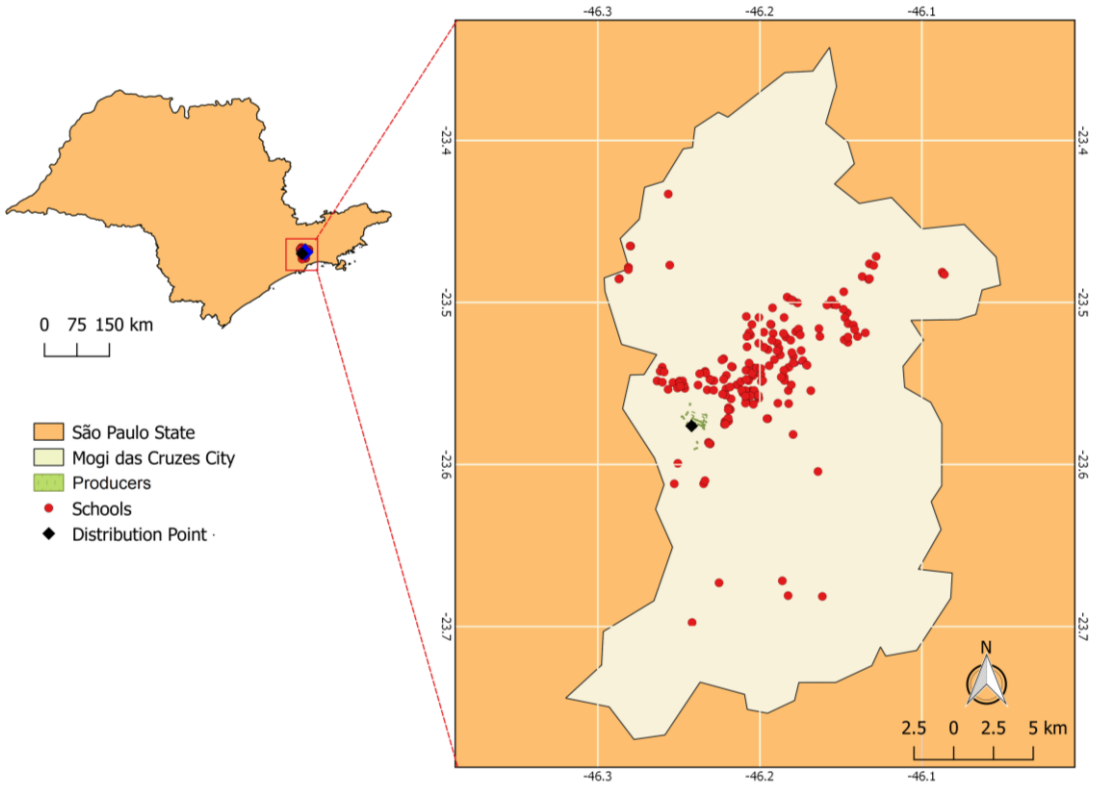

FIGURE 2 – CURRENT DISTRIBUTION POINT AND SCHOOLS. SOURCE: ADAPTED FROM QGIS V. 2.18

4.2 Distribution improvements

The main idea to improve this operation, is locating a new transit point nearer to schools. Thus, vehicles with higher load capacity could send the food from the current distribution point. Shorter routes would be used to attend the supplying network, with a higher quality of pavement and lower losses.

The transit point considered as alternative was the headquarters of the Departamento de Alimentação Escolar (DAE - Department of School Feeding). The address of this department is in an urban area with high concentration of attended schools.

Currently, the DAE manages the provision of school meals maintained by the local government. The number of served meals is about 42,000 every day. At this facility, an industrial kitchen with approximately 300m² of area could process the food received from the local producers. Smaller packages could help handling and storing.

The DAE is the department that takes care of the quality of the purchased food. It is a concerning the quality control of the food bought from the local producers it is sent directly to schools. The DAE has to proceed the quality control. In case of quality problems, the schools report to DAE. The figure 3 shows the schools, the food producers, the current distribution point and the proposed distribution point.

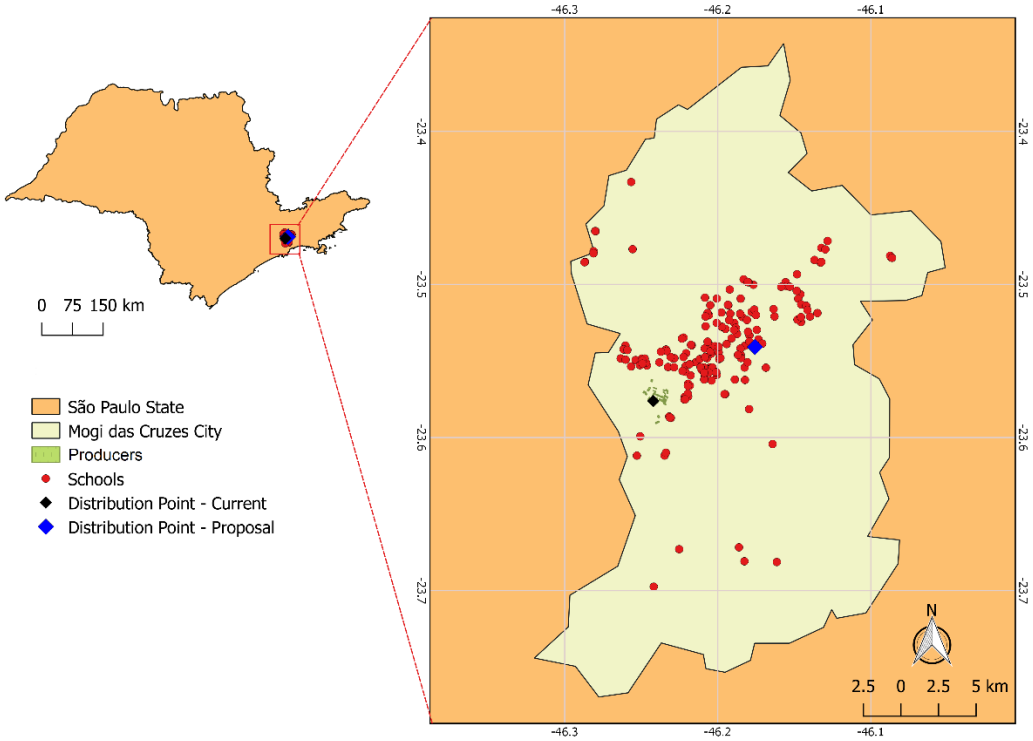

FIGURE 3 - SCHOOLS, PRODUCERS, AND DISTRIBUTION POINTS. SOURCE: ADAPTED FROM QGIS V. 2.18

Besides the smaller distances, there are advantages in changing the distribution point. The government owns the property, where there is an industrial kitchen and food could be processed and repackaged. Smaller packages could be better suited at the premises of the schools. For example, chards with high commercial

value do not fit in the refrigerator and the schools reject them. Another advantage is that the quality control of the food that could happen on site, before sending to schools. The DAE has this assignment, but schools receive foods and do the quality control through not trained people.

The quantities received could be controlled by the team of DAE that is trained and performs this activity every day. As food is sent directly to schools, control of quantities received is also hampered by distance and decentralization. The new distribution point is in an urban area with paved roads.

We developed a hotspot mapping using Kernal density estimation to analyze the concentration of schools. Unlike point mapping showed in figure 4, which focusses on mapping the location of individual schools, hotspot mapping focusses on highlighting areas which have higher concentration of schools.

The new distribution point is in an area with higher concentration of schools if compared with the current distribution point. Some schools attended by operation are still far from the distribution point. The Figure 4 shows the schools in the map with Kernal density analysis.

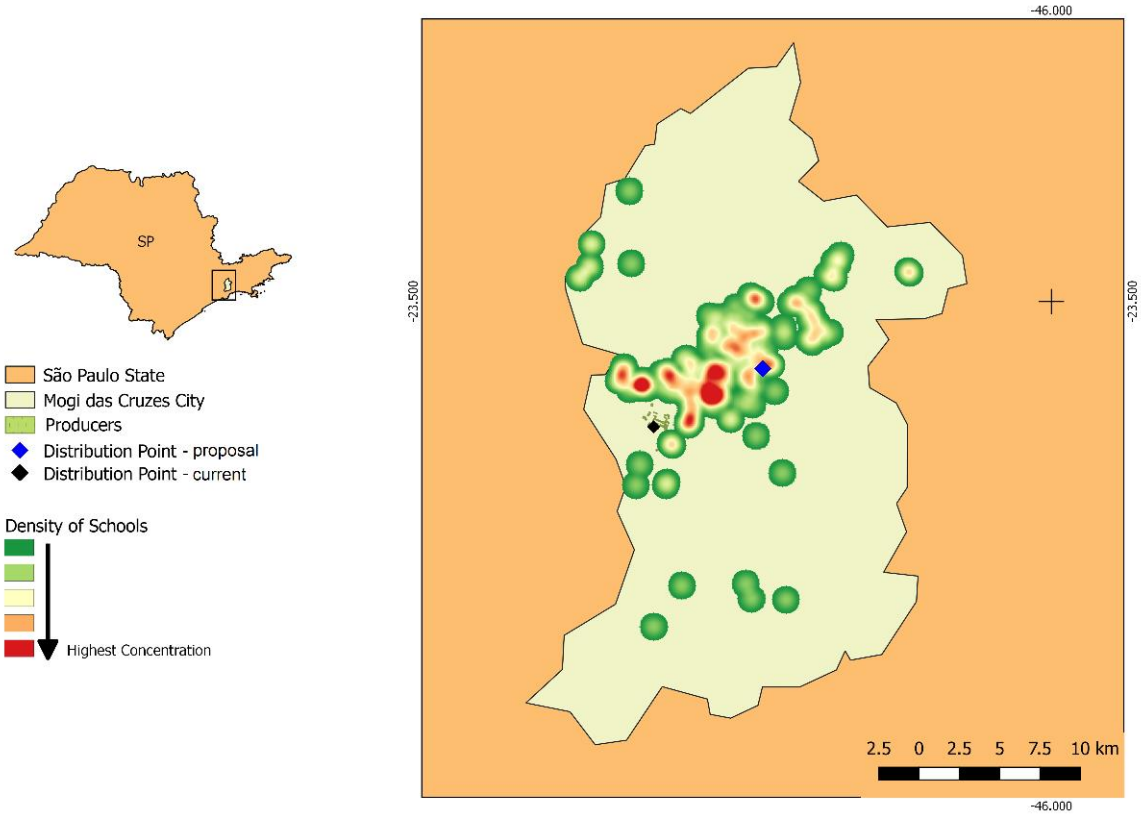

FIGURE 4 – HOTSPOT MAPPING. SOURCE: ADAPTED FROM QGIS V. 2.18

The map shows that the proposed distribution point is in an area with greater concentration of schools. The red areas concentrate a high number of schools. It is noted that the current distribution point that is located in rural area, is further from the urban area, where most of the schools are located. It is not in the central area, but it is in the western part of the city.

We also used a buffer mapping approach to highlight the smaller distances between schools and the proposed distribution point when compared to the current distribution point.

The buffers show that only 26% of the schools are distant up to 5 km of the current distribution point. But 76% of the schools are located within 5 km far from the proposed distribution point

It is seen that a large number of schools are close to the proposed distribution point, if we consider distances up to than 2 km. The current distribution point is surrounded by the food producers. The Figure 5 shows the buffer mapping analysis.

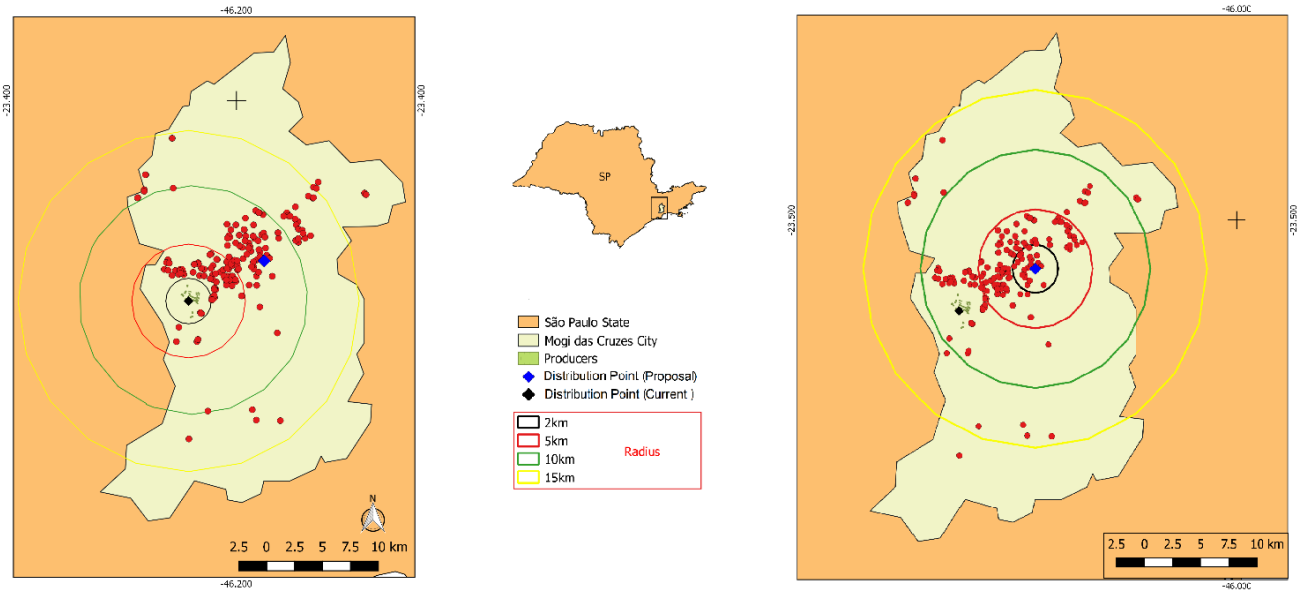

FIGURE 5 – BUFFER METHOD COMPARING THE CURRENT AND THE PROPOSED DISTRIBUTION POINT.
SOURCE: ADAPTED FROM QGIS V. 2.18

5. Conclusion

This study intended to bring ideas about a Brazilian food supply chain related to a national school feeding program in Mogi das Cruzes, one of the most important food producer city in Brazil.

We identified that 58 small local producers supply food for 209 schools. Improvements are very important if we consider the social impacts.

The local government worries about the high costs and the low predictability of the transport operation. This system feeds about 46,000 children daily and thus cannot fail.

The main goal of the current study was to suggest a new distribution point of the food bought from local producers. We looked for a simpler operation with smaller distances and lower costs. This study has also identified that the quality control is unstable because the food is sent to schools and the department that is in charge. The cookers are not qualified people to make decisions about quality levels of food. The local government highlights this issue during this research as a constant concerning.

The findings of this research provide insights into the improvements in the school feeding in Brazil. Mogi das Cruzes is one of the most important food producer city of the country. More than 3,000 small properties supply food for São Paulo city and cities of the green belt of its metropolitan region. Even with a high number of local producers, there are logistics problems that turn the system expensive and inefficient.

We can conclude cities in general, have operational and logistics issues to solve in the context of school

feeding. The present research should prove to be particularly valuable to raise the need for new studies in this area in Brazil.

The information limited the scope of the study because schools were not invited. It will be important to know the problems that schools have to receive, to check, to store and to prepare the meals. More research is needed to better understand this system. We also suggest an application of a simulation model to verify the distances and the time need to attend the schools from the proposed distribution point.

Acknowledgements

We thank the secretaria da agricultura of the city of Mogi das Cruzes city for providing the necessary information to formulate this study. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

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4.3 Capítulo do livro *Food Supply Chains in Cities: Modern Tools for Circularity and Sustainability*

O capítulo com título *Food Distribution and School Feeding: a case study in Mogi das Cruzes city, Brazil* foi desenvolvido após convite dos organizadores para submissão e publicação no livro *Food Supply Chains in Cities: Modern Tools for Circularity and Sustainability - Publisher: Palgrave Macmillian - Crainfield University (UK)*.

O capítulo foi embasado principalmente pelos métodos de análises espaciais adotados no artigo *Developing a system to improve food distribution in public schools: a case in Mogi das Cruzes*. Por diretrizes e interesse dos organizadores do livro, foram abordados assuntos como o cinturão verde de São Paulo, Cadeias de Suprimentos de Alimentos, Programas de Alimentação Escolar e o Programa Nacional de Alimentação Escolar (PNAE), referenciado com frequencia como uma prática importante no contexto global.

Os resultados indicaram que as idéias discutidas no capítulo representam oportunidades de estudos futuros sobre alimentação escolar no Brasil. Também foram levantados os impactos da mudança do ponto de *cross-docking* nas distâncias percorridas na distribuição de alimentos para as escolas da rede.

Developing a System to Improve Food Distribution in Public Schools: A Case in Mogi das Cruzes, Brazil

Background and Aim: School feeding programs are present in different countries. These programs promote healthy feeding through direct buy from local farmers. The aim of this chapter is to analyse the school feeding program by characterizing the food supply chains that involve schools and food producers, in order to propose a new logistics solution that improve the current distribution system.

Research Design and Methods: A case of study of a food supply chain for school system in Mogi das Cruzes, one of the most important food producer cities in Brazil, is presented, where the local farmers supply food for schools, through National Program of School Feeding. Data were collected from the local government and geographic analysis of the network of schools was conducted. Data assessment was performed using spatial analysis, and a Kernel map density analysis to determine the concentration of attending schools and the buffer method to determine the differences between distribution points.

Findings: As a result, a new distribution point and improvements in the logistics operation were proposed. The new distribution point is in an area with a higher concentration of schools (74% up to 5 km), if compared with the current distribution point (26% up to 5 km). Finally, it has been concluded that reducing distances between production and consumption contribute to promote improvements in short food supply chains making the local food production a social and cultural sharing of values and direct incomes for brasilein families.

Research Limitations: The research findings were obtained in an only one case study in a particular situation that entailed a school food program established by Brazilian government, a municipality with specific features such as a developed familiar agricultural production system, and schools located in rural and city areas. Brazil is a country of continental size and more challenges can occur in different ways as well as on a global scale. However, the study is a first step to understand and improve school food distribution systems while ensuring healthy products to the children produced by local family farmers.

Theoretical Contribution: Going in the direction of the current discussion around school food programs and local food, we present a case study has the potential to extend and refine these theories. We offer empirical evidence of the necessity to improve food logistics distribution to the schools that have a direct impact on the feasibility of school feed programs, children nutrition, and surviving of local communities through agricultural production.

Practical impact: Based on research results, local governments looking to improve logistics food distribution to schools could have a benchmarking to adapt to their reality.

Keywords: Local Food; School Feeding; PNAE; Distribution

1 Introduction

School feeding programs are a continuing concern to cities around the world. School-meals provide a protective effect against food insecurity, a negatively impact on educational attainment (Lebersorger & Schneider, 2014; Harvey, 2016; Kristjansson et al., 2016; Belik & Fornazier, 2017; López-Olmedo et al., 2018), enhancing lifelong health and well-being.

A growing body of literature recognises the importance of the food supply chains and the school feeding programs (Sonnino, Lozano Torres, & Schneider, 2014; Chauhan, 2015; Soares, Davó-Blanes, Martinelli, Melgarejo, & Cavalli, 2017; Torres & Benn, 2017). Besides, recent attention has focused on food security, food losses, food wastes, and food supply chains (Kummu et al., 2012; Lebersorger & Schneider, 2014; Bilska, Wrzosek, Kołożyn-Krajewska, & Krajewski, 2016). Moreover, researchers have shown an increased interest in school feeding and food security during childhood (Kristjansson et al., 2016; Belik & Fornazier, 2017; López-Olmedo et al., 2018).

Effective interventions to improve child nutrition can ensure healthy lives and promote well-being. These subjects are related to important matters as food security in childhood, food losses, food wastes, public procurement, and different Food Supply Chains Management challenges. However, to realize these goals, decision makers need to be able to identify which of these interventions are effective and why, so they also need evidence on their costs, such as the cost per outcome and the cost-effectiveness (Kristjansson et al., 2016).

These subjects are related to important matters such as food security in childhood, food losses, and wastes, using public resources, and different aspects of Food Supply Chains management. However, one of the main difficulties for a good performance of school feeding programs is the transport. The mayoralty purchases are coming directly from farming organizations, including those originating from land reform programs and family farmers. From the farmers' side, the new opportunities opened by school meals program procurement disclosed their fragile organization regarding delivery logistics and quality patterns of food provided (Belik & Fornazier, 2017).

For this, it is necessary to take into account the social context that make even higher this challenge. In Brazil, for instance, there are 5,570 municipalities (Brazilian Institute of Geography and Statistics - IBGE, 2017), who receive federal investment for school food programs development. Nevertheless, in this study, the aim is to provide a case study that could motivate the cities in developing similar researches and similar techniques development. For

this reason, the city of Mogi das Cruzes has been selected due to its importance as a food producer city.

Mogi das Cruzes is considered a very important food producer city in Brazil. There are about 3,000 food producers. Using resources of the Programa Nacional de Alimentação Escolar (PNAE – National School Feeding Programme), this food supply system is integrated by 209 schools located at the city´s area that are supplied by 58 local producers consulted by the municipal government.

Brazilian law 11,947 guarantees that 30% of the transferred value by the PNAE must be invested in direct buy of familiar agriculture products. The law stimulates economic development and sustainable communities (Fundo Nacional de Desenvolvimento da Educação [FNDE], 2017).

Taking into account this regulation, nowadays, this system has logistics issues that have been identified regarding the economic impacts on the food transportation. Since the transportation cost I very high, the producers are forced to transport the food until the distribution points located far from the schools making very difficult the last mile food delivery for the schools. In consequence, due to the several food transhipments, there are very tough quality controls when the food finally arrives to the school, making the reception and storage operation very long and tedious. Consequently, considering that the food is bought with public resources, this study raises some questions:

- Is it possible to improve the operation by changing the local of the distribution point?
- In a logic, before-after scenario assessment, what changes could be implemented to help schools regarding its logistics issues?

This chapter attempts to analyse the school feeding program by characterizing the food supply chains that involve schools and food producers in Mogi das Cruzes, in order to propose a new distribution point that improve the current distribution system. Particularly, this study will focus on the improvement on the vegetable supply chains.

To attaint this objective, this chapter is organized as follows: First, a literature review about school feeding programs and studies that investigate distribution and logistics operations is presented. Then, the method used, and the results obtained will be described and discussed. Finally, as a conclusion, a new distribution point will be assessed to improve the current logistics operation of the food supply chain for the food school system.

2 Literature Review

2.1 Local Food Production

Buying local has become indissolubly associated with ethical and socially responsible consumption for a number of motives that reflect its inherent helpful nature in this respect, particularly in the case of food production (Megicks, Memery, & Angell, 2012). There is a growing demand for alternatives to what consumers perceive as industrialized food in the developed markets around the world (Zepeda & Li, 2006). Nowadays, customers prefer chose healthy diets, environmental sustainability, organic foods, natural foods, and raw foods (Lang, Stanton, & Qu, 2014).

Local food purchasing practices behaviour has received considerable interest in recent times. The significance of the topic relates not only to underlying consumer behaviour theory, but also to the perceived role of local food in environmentally responsible purchasing practices, and consequently sustainable food policies. Consumers are no longer satisfied with having a diversity of food to eat; but to eat healthily and sustainably. Many of them want to know where their food comes from and how it has been produced and handled (Megicks et al., 2012).

Many consumers consider local food a more sustainable choice than conventional food because of the shorter transport distances involved as well as the support provided to local economies. In addition, consumers value the perceived safety benefits, ethical associations and improved taste of local food (Autio, Collins, Wahlen, & Anttila, 2013).

Local food attracts considerable policy and public interest, but the evidence is lacking about the emerging contours of the local food sector (Buller & Morris, 2003). Regarding, the consumers who have an interest in local food purchases, they are a segment of the population whose interest in food makes them critical judges of food production. Local food must be fresh and when possible not expensive. Growing this sector requires making local food more accessible through mainstream retail outlets (Lawson & Mirosa, 2012).

In Brazil, there is a relevant inequality in accessing services and infrastructure that ensure urban well-being, especially regarding quality. The wealthier areas, where those with greater purchasing power concentrate, have at their disposal an abundant supply of goods and services, whereas the areas populated by the poor are supplied with less quality goods and services (Machado Bógus & Pasternak, 2010).

Moreover, it is needed to increase the availability of food in many regions of the world and increase peoples' access to healthy food. There are many social-cultural and economic considerations that contribute to local differences in food availability. The interaction between multitudes of factors effectively shows that a "local" approach to addressing many food

challenges must be taken into account. Local solutions need to consider agricultural, environmental and social factors which will differ in importance with location and land use objective (Davies & Ribaut, 2017).

The preservation of viable rural communities intimately linked to local agricultural needs to be given more attention if we are to also preserve and achieve rural social stability (Pollock, 2016).

The literature discusses concepts of Local Food Production (LFP) frequently. The term local food slips effortlessly of the tongue and while an everyday common-sense approach might suggest that local food is produced and consumed within a scarcely well-defined geographical area, there appears to be no generally agreed or widely adopted definition (Jones, Comfort, & Hillier, 2004).

It is difficult to draw conclusions about the local economic impact of local foods systems. Many studies perform narrow geographic and market scope. It is challenging to make comparisons establishing operational, logistics and government support aspects. Consumers are in pursuit of different sources of food produced near their home (Migliore, Schifani, Guccione, & Cembalo, 2014; Nie & Zepeda, 2011).

Micro-scale business concepts have become more common around the world, and there is increasing interest in these among consumers (Migliore, Schifani, & Cembalo, 2015).

While the term “local” food is usually seen, there are no criteria. When asked to use political borders, customers generally define the term as food grown within a county or neighbouring place, or within a certain city or state. Furthermore, political boundaries do not appear to be the best delineation to define local food.

One set of definitions is essentially based on geography and looks to define local in terms of the distance between producers and customers, though there is no clear agreement of a limiting distance, or in terms of local authority boundaries. Thus, one of the definitions of local recognized by the National Association of Farmers’ Markets (NAFM) is in terms of the radius from the market and while the association suggests that 30 miles is ideal, and 50 miles is however acceptable (Jones et al., 2004).

Scaling food production is a world challenge. Encouraging the involvement of mid-sized farms looks to be a classic solution because it can expand the accessibility of local food while providing alternative revenue streams for troubled family farms. Many barriers stand in the way of such a development. The logistical, structural and regulatory barriers to increased scale in local food systems are well known. Limited understanding of the way in which scale developments affect the perception and legitimacy of local food systems can be a relevant matter (Mount, 2017).

Many families that defend the local food production might suggest that important pieces of added value within local food systems are generated by the reconnection of producer and consumer, the direct exchange through which this occurs, and the shared goals and values that provide the basis for reconnection (Mount, 2017).

The needed data to quantify the economic local impact is highly difficult to acquire, and researchers must agree on a standard method of accounting for the costs involved of produced and purchased local foods or on a standard set of economic modelling conventions. Many questions surrounding the economic impact of local foods remain unanswered and could be raised by future researches, e.g., if local food systems help the city-rural economy or if the economic benefits of expanding local food systems might be unevenly distributed (United States Department of Agriculture - USDA, 2017).

According to the 2001 census in Brazil, in 1991, 233,000 people lived in rural areas of Sao Paulo city and in 2,000 that number reached 620,000 inhabitants. It suggests an interesting gap regarding the definitions of what is considered rural and what is considered urban population. This movement has happened mainly in peripheral areas, occupied by informal settlements and irregular land subdivisions. This means this urban population is occupying a rural area, that has lost this main characteristic. Urban population is expanding the boundaries, in areas which are still considered rural by policies and laws (Barbizan, 2011).

2.2 Short Food Supply Chains

Supply chain management concerned the effective integration of interrelated entities making that products are sourced, manufactured and distributed in the correct amounts, to the correct sites and at the correct time, at minimal total system cost (Barbosa-Póvoa & Pinto, 2018).

Food Supply Chain (FSC) management has been attracting increasing attention from the academics and the practitioners because presents characteristics that differ from a standard supply chain such as perishability and high variety. In FSC, much effort has been made to improve the existing standard, regarding issues such as high cost, food waste, food losses and environmental matters (Y. Li, Chu, Yang, & Calvo, 2016).

Managing distribution of perishable products, like food, needs the perpetual control of the environmental conditions of storage and transport facilities to avoid those stresses that may affect their shelf life and quality (Accorsi, Gallo, & Manzini, 2017).

In case of perishable food products, distribution can be abstracted as a vehicle routing problem. It has long been recognized that managing perishable food is a difficult problem, such as vegetables, milk, meat, and flowers distribution (Wang, Wang, Ruan, & Zhan, 2016).

Nowadays, local food has not had strong growth due to specific barriers. One problem is the limited availability in terms of quantity, type of product on demand and year-round products. Over the last few years, more attention has been paid for the Short Food Supply Chains (SFSCs), and how they attempt to reconfigure relationships between producers and consumers in space and time (Paciarotti & Torregiani, 2018).

Short Food Supply Chains (SFSC) allow understanding how and where food is produced, enabling the development of a trust relationship between consumers and producers. The main methods that could help researchers to achieve certainty are implemented to SFSCs in face-to-face relations with consumers and connecting products to their regional features (Aggestam, Fleiß, & Posch, 2017).

SFSCs are more accessible to producers who speak the same language as their consumers and who share similar social, economic and environmental values (Jarosz, 2011). Moreover, SFSC producers attempt to transport produce directly to shops and specialized stores themselves to reduce transport distances. Even though, producers have stated worries over the high costs, also in terms of time, and lack of specialized equipment as smaller or cooled vehicles (Bloom & Hinrichs, 2011).

For farmers, the benefits are economic and social. SFSCs allow for an improved redistribution of the value added and they make farmers less sensitive to market risks, through a decrease in the number of mediators, through diversification, and through better control of prices, guaranteeing less asymmetrical relations with customers (Mundler & Laughrea, 2016).

The barriers to purchasing local food are the limited product availability, the lack in information flow and the logistics barriers. Such criticalities can be faced by introducing a coordinated logistics system and local food promoting, without undermining the short food supply chain principles. The actors will directly interact without the interference of additional intermediaries. The customers will have the opportunity to choose the farmers from which to buy, and they will directly interact with them (Paciarotti & Torregiani, 2018).

Many types of food are highly perishable and fragile. The added value is low and therefore the transport must be efficient with the lowest possible cost. Cross-docking is increasingly used to reduce inventory holding and the time products spend in the supply chain. It is especially suitable for fresh produce distribution with a short shelf-life (Agustina, Lee, & Piplani, 2014).

2.3 School Feeding Programmes

Schools have been considered favorable environments to reverse the health risks that accompany excess weight in children, through providing healthy meals to the child population

(Soares, Martinelli, Melgarejo, Cavalli, & Davó-Blanes, 2017). Persistent malnutrition and the increase in overweight and obesity are a source of concern and schools are considered a site where children can learn about health in general and healthy eating in particular (Torres & Simovska, 2017).

School feeding programmes, present in different countries, promote healthy feeding through direct purchase and sustainable food systems from local farmers. United States, Ghana, Indonesia, Brazil, El Salvador, Honduras, Nicaragua, Paraguay, Niger, Senegal, Ethiopia, Mozambique, and Malawi have incorporated these policies in school feeding programs (Soares, Davó-Blanes, et al., 2017).

Researchers recognize the significance of the School Feeding Programmes (Chauhan, 2015; Soares, Davó-Blanes, et al., 2017; Torres & Benn, 2017). Recent attention has focused on food security, food losses and wastes, and the food supply chains (Bilska et al., 2016; Lebersorger & Schneider, 2014). Food security is the main worry in countless countries. Food production must rise expressively to meet the upcoming demands of an increasing and wealthy world population. In developing countries, school feeding is an important issue for food security through childhood.

School Feeding Programmes are widespread. Global estimations demonstrate that about 370 million children received school feeding in 2012 (Kristjansson et al., 2016). School Feeding Programmes are intended to alleviate short‐term hunger, improve nutrition and cognition of children, and transfer income to families (Jomaa, McDonnell, & Probart, 2011).

Incorporating family farms as suppliers of School Feeding Programmes seems to contribute to an increase in the presence of healthy foods in school meals, the direct purchase of food from family farms represents an opportunity for farms in the municipality to retake food production. The public purchase of food stimulates an increase in agricultural production, in addition to providing for more stable and structured food markets (Soares, Martinelli, et al., 2017).

A research conducted in Jamaica, studied the attending patterns by region of schools which participated in School Feeding Programmes in poor, distant rural areas and determined whether there was a significant difference in attendance over a 10-year period between children who took different lunch types (Jennings, 2016).

In Brazil, the development of direct purchase policies began in 2003 as a part of the Zero Hunger Program. Up until 2003, procurement was based on economic criteria that made participation of family farmers difficult. The purchase of family farm products for use in Brazilian public schools began with the implementation of the Food Procurement Program (Soares, Martinelli, et al., 2017).

Special public procurement programs were developed specifically for family farmers (Brasil, 2003). In 2012, it was estimated that the PAA resulted in the purchase of 374 types of food products from approximately 128,000 family farms (Porto et al., 2014).

The federal Brazilian government encourages a proper nutrition in public schools and the purchase of locally produced foods in small rural properties. The Programa Nacional de Alimentação Escolar (PNAE - National School Feeding Program) provides food and nutritional education of all stages of basic education. The PNAE offers free meals to over 40 million students in Brazil. When it began in the 1950 's, the programme had the goal of addressing malnutrition. The current diet of most Brazilians is of low nutritional quality. The daily consumption of vegetables and fruits is little. The consumption of unhealthy foods is high. The rise in overweight among children ages 5 to 9, has become a new challenge of the program (Soares, Martínez-Mián, Caballero, Vives-Cases, & Davó-Blanes, 2017).

The federal government transfers for public schools, financial values as an additional sum in 10 monthly instalments (from February to November) to cover 200 school days, as the number of students enrolled in each school network. Brazilian law 11,947 guarantees that 30% of the transferred value by the PNAE must be invested in direct buy of familiar agriculture products. The law stimulates economic development and sustainable communities (FNDE, 2018).

Many poor children that live in urban and rural areas depend on the school meals to prevent starving. Funds from PNAE buys food from familiar local farmers located in the city of Mogi das Cruzes. The food feeds students of public schools maintained by the municipal government.

In 1994, Brazilian law 8,913 transferred to municipal governments the responsibility of organizing daily menus, purchasing the ingredients, performing quality control and monitoring the use of resources through the operation of the Conselhos de Alimentação Escolar (CAEs - School Nutrition Councils), which were designed to enhance civil society participation in school food policies (Sonnino et al., 2014).

3 Methods

As mentioned early, the main purpose of this study is to analyse the distribution of food purchased by the local government. The financial resources are obtained from the National School Feeding Programme (PNAE) in Mogi das Cruzes city. Moreover, we investigate how an adoption of a new distribution point could improve this overall logistics operation. The city of Mogi das Cruzes was chosen to this study due to its geographic area which is difficult for access of vehicles to schools, and the interest of the mayor in improving the current system. The city is one of the most important food producers in Brazil.

To perform the presented research in this chapter, we follow these steps:

- First, we obtained the volume of food distribution to schools per type, distance, and frequency of delivery;
- Second, a distribution point was proposed by the local government official food distribution centre. At this facility, is the headquarter of the Department of School Feeding. The team takes care of the operations of the food supply chain, related to the schools feeding program. The shed is in the urban area of the city. As the distribution point is defined, it was not possible to apply other traditional localisation hub methods. We opted to perform a spatial analysis using the methods of a geographic information system. This local was defined as an interesting alternative because the municipality owns the property. In addition, people responsible for the quality of food can carry out an inspection before distribution. And there is the future possibility of using the facilities to process the food so that the packaging after the fresh-cut operation can be suitable for the storage capacity of the schools
- Finally, we used the QGis 2.18© software. This software performed a geospatial analysis in a geographic information system that allowed understanding the current situation. We adopted the buffer method (X. Li et al., 2010; Oliveira et al., 2014), aiming to verify the reaching radius of the new distribution point, and the hotspot mapping using Kernel density estimation (Kernohan et al., 1998; Okabe et al., 2009) to identify the schools' concentration. Justifications for method choices. Where applicable, equations should be numbered and explained.

4 Findings

4.1 Case study context: Mogi das Cruzes

Until the middle of the 20th century, Brazilians were not aware of the wide variety of vegetables before the arrival of Japanese immigrants, characteristically diet from the sea and plants. These immigrants had a key role in Brazilian agriculture, bringing new species of vegetables and food in general. Many Japanese immigrants live in the area called Alto-Tietê region due to upstream of Tietê river, and they have dedicated their entire lives to agriculture. The arrival of these immigrants was established through an immigration agreement between Japan and Brazil at the beginning of the 20th century (Instituto Florestal, 2013).

Among the legacies left by immigrants and their descendants, there are many techniques of agriculture, as the development of new species of vegetables and flowers, including orchids and various foreign dishes (da Silva et al., 2015). For instance, Queiroz (2013) demonstrated

the importance of the green belt of Sao Paulo to preserve the environment, watershed protection areas, and water production. It was concluded, however, that it is difficult in adopting laws on the environment, low management capacity of producers, and obstacles in obtaining financing.

Mogi das Cruzes is considered as the main town in the region of Sao Paulo's green belt, and it has the largest centre of production of vegetables, fruits, and flowers of Brazil, with a relevant share of the national market of mushrooms, persimmon, loquats, vegetables, and flowers. There is a large presence of farmers with Japanese origin (Santos & Bello, 2014). The city is one of the leading mushroom producers in Brazil (Silva, Souza, Jr, & Moretti, 2018) besides is the biggest persimmon producer. The production of persimmon totalled 28% of Brazilian production in 2016 (IBGE, 2018). There are about 2,000 farmers, that supply 35% of the greengrocer market in São Paulo and 5% of Rio de Janeiro city (Prefeitura de Mogi das Cruzes, 2018).

One of the reasons that prompted the declaration of the green belt of São Paulo as a biosphere reserve, it is due to the fact it surrounds one of the planet's largest cities that concentrates 10% of the Brazilian population, with very low rates of green area per inhabitant. The green belt brings a quality of life to the metropolis of Sao Paulo, supplying water and a variety of food. Rivers cut through the urban area, and this region is a habitat of great biodiversity of species, protects the soil from heavy rainfall, and ensures food safety of cities of the metropolitan area (Instituto Florestal, 2013).

The vegetables that are produced in the east region of the green belt, not only in Mogi das Cruzes but also in cities as Suzano, Biritiba-Mirim, and Salesopolis, occurs through a direct transaction with the small local retail or selling the central supermarkets supply chains. In case of sale to supermarket chains, the producer is responsible for the cost of shipping and other fees required by the company, however, it has a regular demand (Sato, Martins, De Carvalho, Milani, & Cunha, 2006).

Mogi das Cruzes city is an important food supplier of the metropolitan region of São Paulo, the biggest city of Brazil. This region is the largest pole of national wealth. The Gross Domestic Product (GDP) corresponds to about 57% of the total of the state of São Paulo. The cities that belong to metropolitan region of Sao Paulo are Arujá, Barueri, Biritiba-Mirim, Caieiras, Cajamar, Carapicuíba, Cotia, Diadema, Embu das Artes, Embu-Guaçu, Ferraz de Vasconcelos, Francisco Morato, Franco da Rocha, Guararema, Guarulhos, Itapevi, Itapecerica da Serra, Itaquaquecetuba, Jandira, Juquitiba, Mairiporã, Mauá, Mogi das Cruzes, Osasco, Pirapora do Bom Jesus, Poá, Ribeirão Pires, Rio Grande da Serra, Salesopolis, Santa Isabel, Santana de Parnaíba, Santo André, São Bernardo do Campo, São Caetano do Sul, São Lourenço da Serra, São Paulo, Suzano, Taboão da Serra e Vargem Grande Paulista.

To illustrate these food distribution issues, we selected Mogi das Cruzes, in São Paulo State. Brazil has 5,572 cities and Mogi das Cruzes is the 1,900º larger city in area in Brazil, with 713 km² (IBGE, 2017). Over 200 schools spread in the urban and rural areas consume food from family agriculture.

4.2 Characterization of the logistic issues

Taking into account that Mogi das Cruzes is the 1,900° larger city in area in Brazil, with 713 km² (IBGE, 2017) and an school system with over 200 schools spread in the urban and rural areas that consume food from family agriculture, one of the most important logistics issues is the location of the current distribution point. The main idea to improve this operation is to locate a new transit point near the schools. Thus, vehicles with higher load capacity could send the food from the current distribution point. Shorter routes would be used to attend the supplying network, with a higher quality of pavement that could result in lower food losses.

The current distribution point and storage shed is far from most schools, and the quality of the roads is poor (Fig 1). Many of them are not paved, bringing an extra challenge to the distribution operation.

Figure 1 Current distribution point. Source: Authors

Figure 2 shows the familiar producers, the current distribution point, and the schools.

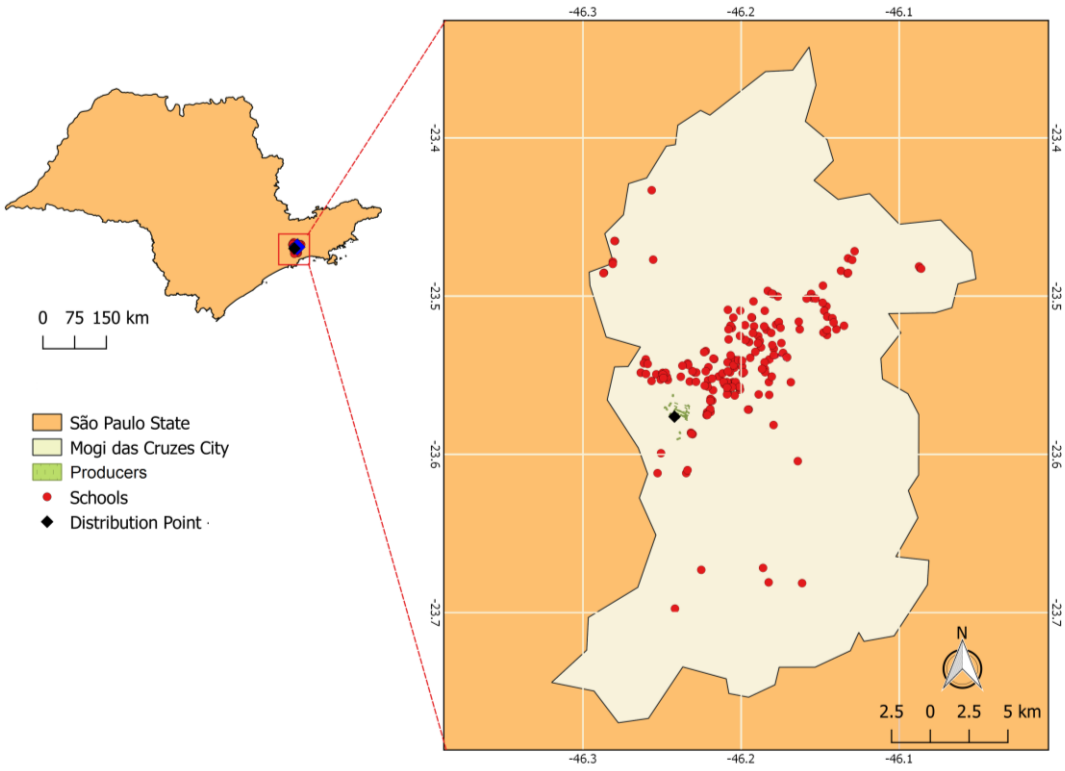

Figure 2 Producers, current distribution point and schools. Source: adapted from QGIS 2.18 (2018)

Note that the current distribution point was established by the producers in their territory as part of the cooperative system. They did not consider the distance to schools and logistics impacts. It is possible to infer that they did have not a previous plan or analysis of the impact of this solution.

4.3 New distribution point proposal

Taking into account that vehicles with higher load capacity could send the food from the current distribution point to the new distribution point. Shorter routes would be used to attend the supplying network, with a higher quality of pavement that could result in lower food losses.

At this facility, an industrial kitchen with approximately 300m² could perform the fresh-cut process with the food received from the local producers, Figure 3. The fresh-cut is defined as fresh leafy greens whose leaves have been cut, shredded, sliced, chopped, or torn. The term “leafy greens” includes lettuce, escarole, cabbage and chard (Choi, Norwood, Seo, Sirsat, & Neal, 2016). The fresh good may be easily spoilt during delivery, which leads to many returned products. Therefore, an efficient logistics operation is crucial (Guo, Wang, Fan, & Gen, 2017).

Figure 3 New distribution centre. Source: Authors

The team of municipality's school feeding department performs a wide range of activities as standardization of menus for children's schools and elementary education, annual schedules for the delivery of foodstuffs: breads, cakes, meats and sausages, vegetables, grocery products and juice, special menus for children with pathologies such as diabetes, phenylketonuria, lactose intolerance and malnutrition, elaboration and distribution of the Handbook of Good Food practices for all schools, conducting research on general food consumption per region, conducting monthly visits of supervision and guidance to the units served by the department and quality control of food.

The team could verify the quality of the purchased food as well before sending to schools. It is relevant concerning the current transport operation. The food bought from the local producers is sent directly to schools without any inspection. In the hierarchical organization, there is a director that commands a group of procurement analysts and the inbound logistics employees (forklift operators and inbound logistics assistants). Figure 4 shows the location of the proposed distribution point.

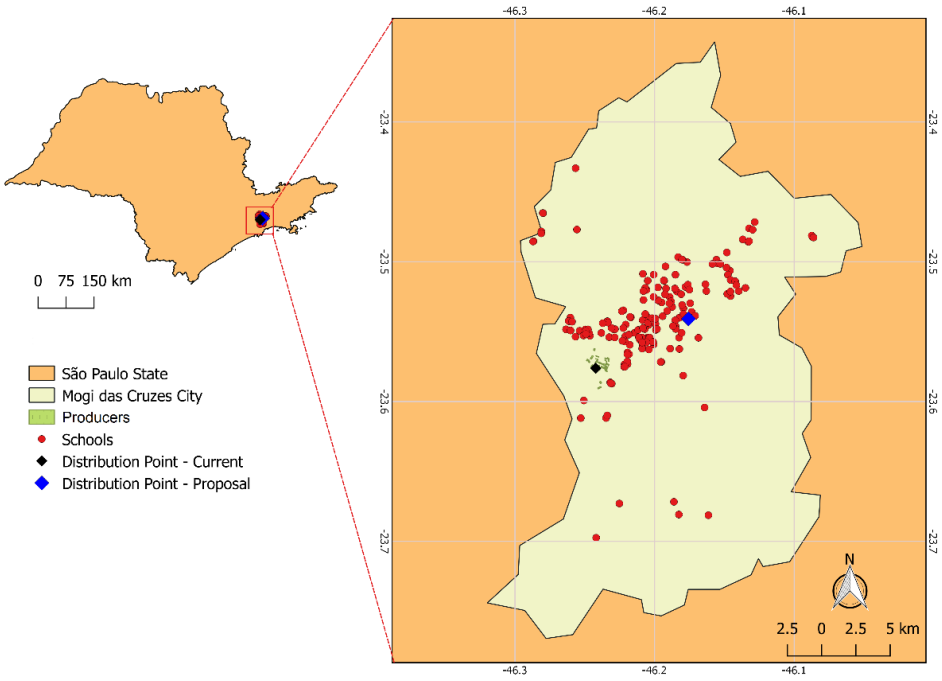

Figure 4 The proposed distribution point. Source: adapted from QGIS 2.18 (2018)

We performed spatial analysis, using a Kernel map density analysis to determine the concentration of attending schools and the buffer method to determine the differences between both distribution points.

The new distribution point is in an area with a higher concentration of schools, if compared with the current distribution point. In any case, a few schools attended by the familiar food producers are still far from the new distribution point. Figure 5 shows the schools on the map with Kernel density analysis.

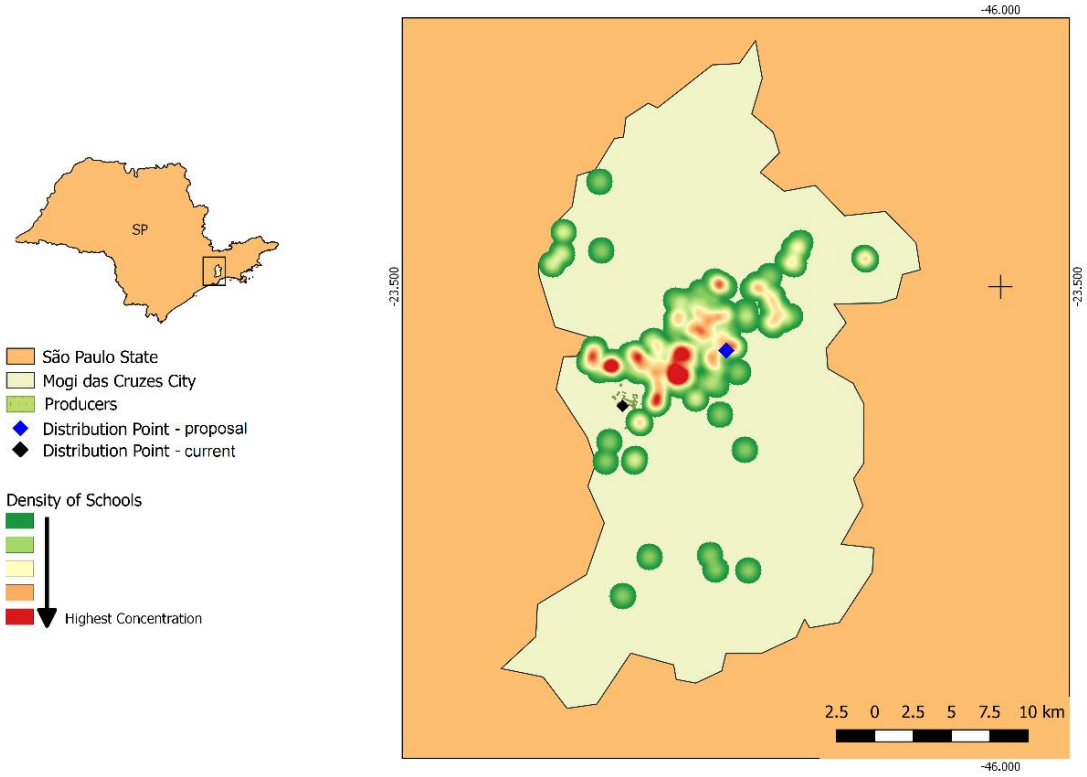

Figure 5 Kernal map analysis. Source: adapted from QGIS 2.18 (2018)

We also used a buffer mapping approach to highlight the smaller distances between schools and the proposed distribution point when compared to the current distribution point.

4.4 Solution assessment

The buffers show that only 26% of the schools are distant up to 5 km of the current distribution point while 74% of the schools are located within 5 km far from the proposed distribution point, Table 1.

Table 1 Schools distance. Source: Authors

	Distribution point	
Distance	Current	Proposed
up to 2 km	1,0%	10,0%
up to 5 km	26,0%	74,0%
up to 10 km	85,0%	93,0%
up to 15 km	99,0%	99,5%

It is seen that a relevant number of schools are near to the proposed distribution point, if we consider distances up to than 2 km. The current distribution point is surrounded by the food

producers and then the total distance for inflows from food producers is short. Many producers are neighbours of the association and they deliver the food using small vehicles. Eight urban delivery vehicles attend 209 schools. The longest route serves the most distant schools in the south region of the city and measures about 70 km. The other shorter routes are most driven in the urban area.

The longest route in the north region measures about 40 km. Moving the distribution point, the longest route in the south of the city would not be improved. On the other hand, delivering fresh-cut food improves the vehicle's load capacity. Figure 6 shows the buffer mapping analysis comparing the current and the proposed distribution point.

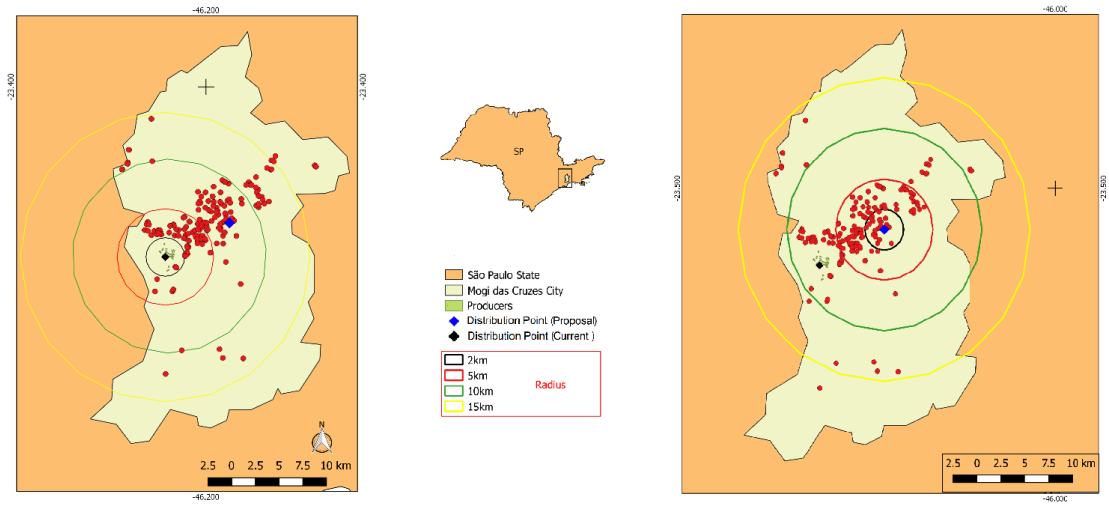

Figure 6 Buffer method analysis. Source: adapted from QGIS 2.18 (2018)

Note that is a striking difference between the current distribution point and the proposed one. The new is more balanced and provide a better distribution system. Moreover, the new point is more prepared to attend logistics need and it is able to semi-processed food before to send to schools. This can increase the expiring date of agricultural products.

5 Discussion

The findings of this research provide insights into the improvements in the National School Feeding Programme in Mogi das Cruzes is one of the most important food producer cities of the country. More than 2,000 small rural familiar properties supply many types of food for São Paulo city and cities of the green belt of its metropolitan region. Even with a high number of local producers, many logistics problems make the logistics operation expensive and inefficient.

We can infer that cities in general, have operational and logistics issues to solve in the context of school feeding. These matters make it difficult to grow sustainably with the expansion of the National School Feeding Programme, bringing social losses. The present research should prove to be particularly valuable to raise the need for new studies in this area in Brazil. The new approaches could include operational research methods as discrete event simulation and linear programming. As the scenario is complex, with diverse players, it is viable to apply multi-criteria methods as Analytic Hierarchy Process (AHP) to determine alternatives that could improve the short food supply chain, considering different points of view (Choi et al., 2016; Rabello Quadros & Nassi, 2015; Zhao et al., 2018).

Sharing concepts of local food, advances as social and cultural sharing of values and direct incomes for families, are benefits of promoting improvements in short food supply chains.

Reducing distances between production and consumption include an inclination to contribute to producing and distributing food according to horizontal relationships and ethical values (Hinrichs, 2003). It includes the disposition of a decrease of fossil fuel-based transportation as well (Rothwell, Ridoutt, Page, & Bellotti, 2016) and considers the economic and environmental impact of city food logistics systems.

6 Conclusions

The National School Feeding Programme (PNAE) in Brazil plays an important role in the local economy. Between 2016 and 2018, more than BRL 9,000,000,000 were passed by the Brazilian government to state and municipal schools and day care centres. In 2017, about 41 million students were benefited (Brasil, 2017).

Suppliers of agricultural inputs, familiar producers, carriers and attended schools are ties of these Food Supply Chains. Operational and logistical improvements in this programme can motivate new familiar producers to provide food for the local government and motivate current food producers to continue providing food in larger quantities, providing scale gains for the system.

Our research proves with simple measures is it possible to improve operational efficiency. In this specific case, the study shows that a move of the current distribution point for a centre facility allows attending 74% of schools of Mogi das Cruzes city transporting goods less than 5 km. Moreover, the new facility has the condition of pre-processed agricultural foods originated from PNAE program to familiar agricultural of Brazilian government that increases expiring date of products.

The results of this research will be used by Mogi das Cruzes government to prove the necessity of this move. How the facilities belong to the secretary of education and agricultural farms are linked to the secretary of agriculture, some arrangement needs to be done to allow this move. However, this research has fundamental relevance in highlight this necessity.

Furthermore, this study may help other Brazilian cities with comparable geographic characteristics, that buy food from family farmers to offer in school meals. The management difficulties of logistics operations are similar. Reducing logistics costs and bringing a higher understanding of this system can produce public transparency of the PNAE.

Finally, for future research, it is important to apply operations research methods, as discrete event simulation and linear programming, aiming to improve the overall distribution system. The used method in this study does not allow to analyse additional indicators as system cost and total distance travelled.

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4.4 Artigo III

O artigo *Food Distribution for Primary Schools in Brazil: An Analysis of Product Flows in a Short Supply Chain* foi elaborado para análise quantitativa dos fluxos de alimentos na rede de escolas públicas, sendo submetido para revista qualificada nos extratos Quais A1 e A2 e primeiro percentil scopus.

As informações obtidas por meio de contatos com as Secretarias da Agricultura e da Educação, mostraram as quantidades dos 13 tipos de alimentos consumidas pelas 209 escolas da rede, em unidades (maços, unidades) e em quilos. Também foram disponibilizadas informações sobre quais cooperativas forneceram os alimentos. Todos os dados são referentes ao ano de 2017.

Várias redes foram elaboradas. Os nós considerados foram as cooperativas, os alimentos e as escolas. Os arcos são as relações entre esses nós.

O *software* UCINet foi utilizado para cálculo das métricas *Degree Centrality* e *Betweenness Centrality* e para a elaboração de redes com pesos das relações (quilos e unidades). O *software* NetDraw foi utilizado para a vizualização das redes elaboradas.

As análises em redes permitiram maior entendimento sobre a demanda dos diversos tipos de alimentos das escolas, das diferenças das relações entre alimentos e cooperativas e dos impactos do volume e do peso dos alimentos na operação de distribuição.

A visão ampliada das redes representaram grande avanço nas conclusões e no alcance dos objetivos da pesquisa.

Food Distribution for Primary Schools in Brazil: An Analysis of Product Flows in a Short Supply Chain

School food programmes have been used to confront malnutrition. However, distributing food in school canteens is a challenge for many municipalities around the world. In Brazil, the situation is not much different, and in an attempt to educate students on how to eat and prevent malnutrition, Brazilian National School Food Programme has offered free, balanced meals for students in basic education since the 1950s. With more than 5,000 municipalities, the country faces issues of logistics, food availability and public administration to keep the programme running. This article investigates the movement of vegetables produced on family farms in Mogi das Cruzes to 209 schools in the region to identify the main issues related to food supply management and logistics. Using a social network approach based on a database and field research, the results showed that the main issues are concerned with standardizing distribution patterns and regulating supply and demand.

Keywords: School Feeding Programs; Social Network Analysis; Brazilian National School Feeding Program; supply chain management; logistics

1. Introduction

Malnutrition refers to deficiencies, excesses or imbalances in the human diet (WHO, 2019). Usually, it is associated with a combination of factors, such as insufficient protein, energy and micronutrients, frequent infections or disease, poor care and feeding practices, inadequate health services and poor water and sanitation (UNICEF, 2016).

School feeding programmes have been used in various countries to confront malnutrition and keep children in school (Fernandes, 2018). Such programmes improve incomes and food security in local communities (FAO, 2018). For instance, since its adoption in the 1950s, the Brazilian School Feeding Programme [Programa Nacional de Alimentação Escolar (PNAE)] has offered free, balanced meals to students in kindergarten, primary school and secondary school (Locatelli, Canella and Bandoni, 2018).

Despite the success of the programme, logistics remains a challenge for municipalities owing to food perishability, poor infrastructure and lack of knowledge of the people involved. Therefore, mayors have the challenge of dealing with food distribution, which influences the operating costs and availability of products to the schools.

Although the need for school food programmes to fight malnutrition and keep students in school is clear, how can the availability of adequate products to schools be ensured? There is no doubt that processed products can be easily distributed and stored because they use the correct packaging and have a long expiration dates. However, they lack some of the essential nutrients that are present in natural products such as vegetables and fruits. In Brazil, these kinds of products are common in peoples' diets owing to the country's rich farming areas and low prices. Around 30% of PNAE resources are used to buy these products, mainly from family farms. These vegetables are organic, fresh and have a massive impact on ensuring a balanced diet.

What are the challenges for the logistics and distribution of vegetables produced on family farms to school feeding programmes? What does this imply for food supply chains?

With these questions in mind, this paper investigates the movement of vegetables bought with resources of the Brazilian National School Feeding Programme, from family farms to school canteens in the city of Mogi das Cruzes, Brazil. The city was chosen for its unique situation, which involves urban and rural schools near a large vegetable production area.

The rest of this paper is structured as follows: Section 2 provides a review of the existing literature. Section 3 describes the methodology, whereas Section 4 presents the main results. Finally, in Section 5, the findings and conclusions are presented.

2. Literature Review

2.1 School feeding programmes in Brazil

Many authors highlight the role of school feeding programmes in ensuring food security and avoiding malnutrition (Sonnino, Lozano Torres, and Schneider, 2014; Chauhan, 2015; Soares, Martínez-Mián et al., 2017; Torres and Benn, 2017). Kristjansson et al. (2016) confirm that approximately 370 million children benefited from school feeding programmes in 2012.

In Brazil, the federal government encourages adequate nutrition in public schools and the associated purchase of 30% of the vegetables and fruits from local family farms (FNDE, 2017). The programme, called the 'National School Feeding Programme', is a system that provides food and nutrition to students in all stages of basic education.

This programme began in the 1950s to deal with undernourishment and nowadays provides free meals to over 40 million students. It consists of a transfer of funds for public schools in ten monthly instalments (from February to November) to cover 200 school days of student feeding (Soares, Davó-Blanes et al., 2017). The municipalities manage these funds and centralize their purchases through two secretariats: Education and Agriculture.

The first studies of the National School Feeding Programme started in the 1930s, when it was recognized that starvation and malnutrition were a public health issue (Peixinho, 2013). However, it was not implemented owing to a lack of resources. In 1955, the country finally created a programme to address malnutrition issues in children, with the financial support of the United Nations Children's Fund (UNICEF). Since then, the programme underwent some changes and in 1979 the name was changed to PNAE. Nonetheless, the programme only became a government obligation after the federal constitution of 1988 (FNDE, 2017; Peixinho, 2013).

From the beginning, management of the programme was centralized in the Ministry of Education, but in 1994 the funds were decentralized to local governments. In 2001, it was determined that 70% of resources would be spent on basic products, respecting the regionalism of each area (FNDE, 2017).

In 2000, the School Food Council [Conselho de Alimentação Escolar (CAE)] was created to inspect the use of resources with representation from civilian society, education labour, students, parents and government. In 2006, schools were obliged to engage a nutritionist to control the menus (FNDE, 2017).

The National School Feeding Programme is recognized worldwide, and the Food and Agriculture Organization (FAO) uses it as a model to implement similar programmes in Africa, Asia, the Caribbean and Latin America (FNDE, 2017). In 2010, more than 45 million students participated in the programme in Brazil (Peixinho, 2013).

2.2 Short food supply chains and family farms

Food supply chain management has been attracting attention from academics and practitioners because of its unique restrictions and objectives related to costs and consumer expectations, which are becoming more demanding, expecting healthy, safe and available food all year round (Miranda-Ackerman and Colín-Chávez, 2018). Compared with traditional supply chains, the components of food supply chains are more likely to decay quickly because they deal with perishable products (Chen et al., 2013).

Jonkman, Barbosa-Póvoa and Bloemhof (2018) address the idea that food supply chains can be split into agro-food supply chains, which cope with agro-materials. Agro-materials are converted into a number of semi-finished and finished products with animal or plant origins. Although

vegetables may be included in agro-food supply chains, in this particular case, the concept that better defines the flow of vegetables from family farms to schools seems to be linked to the idea of short food supply chains (SFSC).

The concept of the food supply chain revolves around the idea of ‘farm to fork’, in which raw material is transformed as it goes through multiple stages (Dani, 2015). However, some researchers are discussing the shortness of the food supply chain (Aggestam, Fleiß and Posch, 2017), which can be directly linked to the case of school food programmes that purchase vegetables from farms instead of retail outlets. These micro-scale business concepts have become more common around the world, and there is increasing interest in them among consumers (Migliore et al., 2015).

The acceptance of the SFSC term in recent years is attributed to a distributive model that permits customers to support local agriculture and increase the amount of fresh foods in their meals (MacMillan Uribe et al., 2012).

SFSC allow an understanding of how and where food is produced, enabling the development of a robust pledge of trust between consumers and producers (Aggestam, Fleiß and Posch, 2017). Moreover, they are more accessible to producers who speak the same language as their consumers and who share similar social, economic and environmental values (Jarosz, 2011b).

Producers in short supply chains usually transport the produce themselves, directly to shops and specialized stores, in order to reduce transportation costs. However, they have shown concerns about the high costs, time requirement and lack of specialized equipment, such as smaller or refrigerated vehicles (Bloom and Hinrichs, 2011).

For farmers, the benefits are both economic and social. SFSC allow for improved redistribution of the value added, and they make farmers less sensitive to market risks through a decrease in the number of intermediaries, through diversification and through better control of prices, guaranteeing less asymmetrical relationships with customers (Mundler and Laughrea, 2016).

Regarding global food supply chains, the contribution of family farmers to food security and local and regional development is poorly documented (Graeub et al., 2016). In 2014, the FAO developed the first comprehensive report on family farming and estimated their number as at least 500 million, being responsible for about 80% of the world's food production (FAO, 2014).

Family farming in Brazil comprises 4.37 million farms (84% of all holdings) on 24.3% of the total agricultural area, engaging 74% of the agricultural labour and being responsible for 38% (USD 27 billion) of gross annual value (Graeub et al., 2016). These numbers affect government decisions that intend to increase the volume of food for school feeding programmes that originates on family farms. With an infrastructure that aims to help big farms in the high production of soybean and corn for export, the logistics of family farms, especially those in SFSCs that are local, is a huge challenge for municipalities.

3. Methodology and Data Processing

3.1 Social network analysis

Social network analysis (SNA) plays a key role in studies of economics, management and sociology (Huang, Wang and Chen, 2019). It establishes patterns of relationship between nodes representing people and groups in order to identify the most influential nodes (Yustiawan, Maharani and Gozali, 2015; Palomo-Campesino et al., 2018; Cadena et al., 2018). These nodes have the ability to influence the decisions in a network (Kim et al., 2011).

Network models present designs of relations in which actors are represented by nodes and relationships are represented by arcs (Cheah and Shimul, 2018). Because of their ability to identify the influence of actors and strengths of relationships described by flows of information, money, products and so on, this technique has been incorporated into economics, mathematics, sociology, industrial thinking and supply chain research.

SNA has been proposed as a powerful tool for investigating trade flows and the role of trade partners (Lovrić et al., 2018), where studies of supply chains and logistics can be built with a social network perspective (Choi, Dooley and Rungtusanatham, 2001). Social network theory is a valuable instrument for studying supply chains and can support research into logistics and supply chain management (Ketchen Jr. and Hult, 2007; Borgatti and Li, 2009).

Supply chain managers can benefit from the application of SNA within their companies to improve the understanding of the complex relationships that drive organizations (Hollenbeck and Jamieson, 2015). Moreover, they can use this knowledge about SNA to investigate the structure of their suppliers' networks and identify nexus suppliers that are not visible to the focal company, as such relationships are usually indirect and of low mutual dependence (Yan et al., 2015).

The network can be analysed in terms of degree centrality and betweenness centrality. Degree and betweenness centralities are essential metrics in SNA (Krackhardt, 1990; Everett and Borgatti, 1999; Marsden, 2002). The former counts only direct ties, whereas the latter includes longer paths (Agneessens, Borgatti and Everett, 2017).

3.1.1 Degree centrality

Degree centrality can be defined as the number of nodes to which a specific node is directly connected, i.e. the number of nodes reached through a single step and without the need for any

intermediary (Agneessens, Borgatti and Everett, 2017). Therefore, only the local structure around a node must be known in order for it to be calculated (McPherson, Smith-Lovin and Cook, 2001). This measure is a primary indicator and is often used as a first step when studying networks (Freeman 2004; Wasserman and Faust, 1994).

This concept builds an observation of the number of links that a node has. A node will be more central when it is linked to many actors. Owing to its greater connectedness with other nodes, one with high degree centrality would necessarily be more visible in the network (Kim et al., 2011).

Degree centrality in a supply chain is measured by the number of direct ties to a node (Wasserman and Faust, 1994; Kim et al., 2011; Wichmann e Kaufmann, 2016):

$$C_d\,(n_i\,) = \sum_j x_{ij} \qquad (1),$$

where $C_d\ (n_i)$ is the centrality degree for a node i and $xij\ or\ xji$ is the binary variable equal to 1 if there is a link between ni and nj. Otherwise, it is equal to 0 (Nieminen, 1973; Freeman, 1978). Wasserman and Faust (1994) highlighted that one problem with this measure is that it depends on the group size (g), where the maximum value is $g-1$. Therefore, a standardization of this measure is normalized as the proportion of nodes adjacent to n_i, as shown in Eq. 2 (Wasserman and Faust, 1994; Kim et al., 2011). This value can be transformed to a percentage by multiplying by 100:

$$C'_d(n_i) = \frac{C_d\,(n_1)}{g-1}\ x100 \qquad (2)$$

In this case, $C'_d(n_i)$ is independent of g and can be compared in networks of different sizes (Wasserman and Faust, 1994).

A better approach to studying degree centrality is to analyse where the flow starts and ends. In a directional network of product flow, the emphasis is on the flow initiated (out-degree) or received (in-degree). In-degree centrality and out-degree centrality respectively indicate the size of the adjacent upstream and downstream tiers (Powell, Koput and Smith-Doerr, 1996).

The out-degree centrality of a node is defined in Eq. 3 (Wasserman and Faust, 1994):

$$C'_d out(n_i) = \sum_{j=1}^{ni} X_{ij} \quad (3)$$

In this study, out-degree centrality investigates the connections between suppliers and schools, and between products and schools. This measure allows us to identify the roles of suppliers and essential products in our network.

The in-degree centrality of a node is defined in Eq. 4 (Wasserman and Faust, 1994):

$$C'_d in(n_i) = \sum_{j=1}^{ni} X_{ji} \quad (3)$$

A high in-degree centrality may attend the role of integrator, which coordinates product development, production and logistics from product concept to delivery (Parker and Anderson, 2002). In our case, the in-degree measure relates to the role of schools in the network.

3.1.2 Betweenness centrality

A node can lie between a pair of non-adjacent nodes, along either their material flow or contractual relationship. In graph theory, betweenness is developed mainly as a metric, studied using the shortest path in a connected graph (Changat, Narasimha-Shenoi and Seethakuttyamma, 2018). Betweenness centrality begins with the assumption that a connection between two nodes, n_j and n_k, follows their geodesics. Therefore, betweenness centrality can be expressed as Eq. 4 (Freeman, 1977; Wasserman and Faust, 1994; Kim et al., 2011; Wichmann and Kaufmann, 2016):

$$C_B(n_i) = \sum_{j<k} \frac{g_{jk}(n_i)}{g_{jk}} \quad (4)$$

where g_{jk} is the total number of geodesics linking the two nodes, and $g_{jk}(n_i)$ is the number of those geodesics that contain n_i. The n_i betweenness is the sum of the probabilities that the node lies between other nodes, as shown in Eq. 5. It is normalized to a value between 0 and 100 (Kim et al., 2011):

$$C'_B(n_i) = \frac{C_B\,(n_i)}{[(g-1)x(g-2)/2]}\ x\ 100 \quad (5)$$

Betweenness centrality measures how often a node lies on the shortest path between all combinations of pairs of other nodes. The more a node connects nodes that would otherwise be disconnected, the more central that node is. Nodes are dependent on this node to reach out to the rest of the network. This metric focuses on the role of a node as an intermediary (Kim et al., 2011). Betweenness centrality is generally regarded as a measure of other nodes' dependence on a given node and therefore as a measure of potential control. Betweenness is commonly assumed to be related because of its conceptual duality concerning dependency and because both are defined based on the shortest paths (Brandes, Borgatti and Freeman, 2016).

Betweenness measures the degree to which a node lies on the shortest path between two other nodes and can conduct the flow in the network. Thus, a node can assert control over the flow. However, this metric considers the global network structure and can be applied to networks with disconnected components (Opsahl, Agneessens and Skvoretz, 2010). High betweenness can indicate a hub or pivot that links actors along the supply chain. It relates to the extent to which a node affects the downstream operations and eventually the performance of the whole network.

3.2 Data source

Data were obtained from the local government of the city of Mogi das Cruzes, Sao Paulo, Brazil. We requested information about the consumption of different types of food distributed to public elementary schools and which products were related to family farms. All of the products were paid for with National School Feeding Programme funds. Official data was available for the year of 2017.

The city of Mogi das Cruzes is located in the metropolitan area of Sao Paulo. Despite this fact, it encompasses a huge agricultural production area and is considered one of the most important food producing cities in Brazil. There are about 3,000 farms within the town. Using the financial resources of the Brazilian National School Feeding Programme, the municipal government buys vegetables from 58 local producers to supply 209 schools located within the city's area to achieve the legal requirement of 30% of products originating from family farms (FNDE 2017).

The main obstacle to good performance of school feeding operations in the city involves regulating supply and demand to facilitate logistics operations.

To understand this process, additional data were collected through empirical research by the Secretary of Agriculture and Secretary of Education of Mogi das Cruzes, family farm cooperatives and transportation operators.

Data Analysis

The data were arranged in matrices using Microsoft Excel 16©, in which cooperatives, food types and schools (nodes) were related (i, j). First, we assigned '1' when the food type i was delivered to a school j or when a cooperative produced the item; we assigned '0' otherwise. These relations allowed us to identify the degree and betweenness centralities. Then, we prepared different matrices, substituting '1' for the volume in kilograms or number of packages. The matrices were then imported into the UCINET 6© software.

UCINET is the most frequently used software package for social network analyses (Wichmann and Kaufmann, 2016; Ahuja, Polidoro and Mitchell, 2009; Everett and Borgatti, 2012; Jaewoo and Woonsun, 2014; Chandra and Joba, 2015; Mohammadfam et al., 2015; Yu and Shi, 2015; Molano and Polo, 2015; Celik and Corbacioglu, 2016; González Motos, 2016; Kangbai, 2016;

Etemadi et al., 2017; Han, Zhu and Zhao, 2017; Gyarmathy et al., 2017; Deng et al., 2018; Palomo-Campesino et al., 2018).

Besides identifying empowerment network relations between companies and people, UCINET creates network visualizations (Kim et al., 2011). These network displays can be generated using the Netdraw© module. It employs multi-dimensional scaling, a useful method for understanding the 'internal structure of the group' by physically positioning actors based on their relational attributes so that similar actors are graphically situated closer together, while dissimilar actors appear farther apart in that space (Johnson et al., 2009; Nielsen et al., 2009; K. Hosseinzadeh and Kazemi, 2012; Bae et al., 2015; Oliveira, Mendes and Rozenfeld, 2015; Monaghan, Lavelle and Gunnigle, 2017; Kjos and Bryant, 2018).

4. Results

As previously mentioned, this article aims to investigate the movement of vegetables between family farms and school canteens in the city of Mogi da Cruzes, Brazil as part of the PNAE programme. We present the main results below.

4.1 Network relationship

Our specific case entails three cooperatives, 209 schools and 13 vegetables. A visualization of the network is shown Fig. 1.

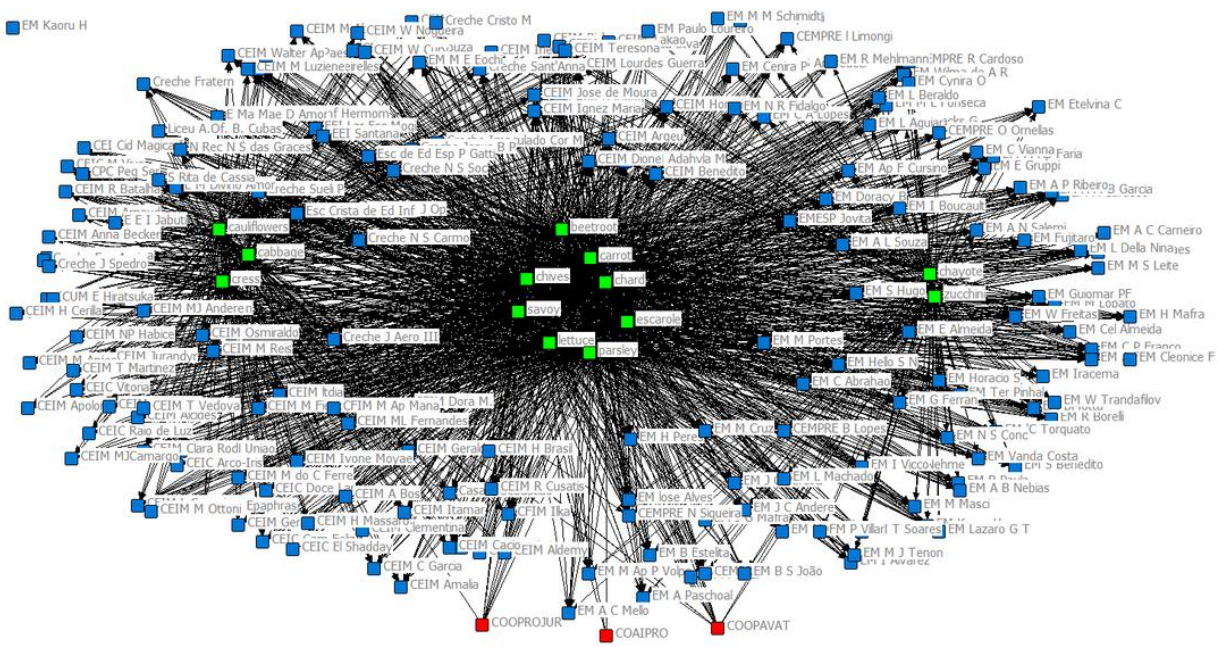


Figure 1. Cooperatives, vegetables and schools network.

Cooperatives (red squares), schools (blue squares) and vegetables (green squares) are nodes, and the ties represent each food type delivered to the various schools. To build this network, we used matrices with values of 1. The idea was to graphically represent the network and analysis clustering.

The graphical analysis allowed us to identify three groups of vegetables and schools, as shown in Fig. 2.

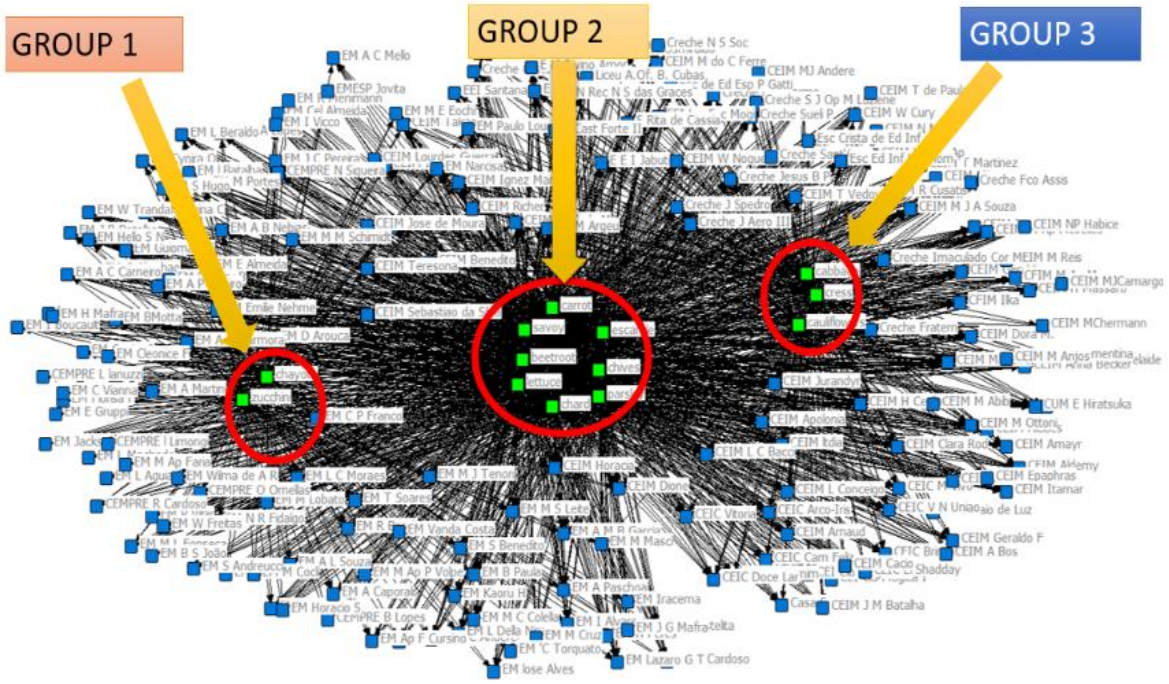


Figure 2. Groups of distribution.

Chayote and zucchini are in the first group. These vegetables are consumed by the same set of schools, which represents approximately half of the total number of schools. Beetroot, carrots, chard, chives, escarole, lettuce, parsley and savoy are in the second group. They are consumed by the most of the schools. Cabbage, cress and cauliflower are in the third group.

Note that the schools in the group that consumes chayote and zucchini are similar and avoid the consumption of cabbage, cress and cauliflower.

Beetroot, cabbage, carrots, chard, chives, escarole, lettuce and parsley reach almost all of the schools, as they are central nodes in the network. This fact can denote a higher logistical effort for these items in the distribution.

4.2 Degree centrality (in- and out-degree)

To confirm the graphical results, we used a quantitative metric analysis. First, we checked the out-degree that corresponded to the types of vegetables sent to school and cooperative flows. Table 1 shows the out-degree metric of this network.

Table 1. Out-degree

Food type	Number of schools (Out-degree)	Normalized Out-degree
Parsley	202	93.953
Lettuce	202	93.953
Chard	202	93.953
Savoy	202	93.953
Escarole	202	93.953
Carrot	201	93.488
Chives	201	93.488
Beetroot	200	93.023
Cauliflowers	116	53.953
Cabbage	113	52.558
Cress	111	51.628
Chayote	108	50.233
Zucchini	107	49.767

The results indicate that eight of the 13 vegetables were delivered in more than 200 schools. Five of them are essential ingredients in Brazilian food nutrition. The normalized degree relates the percentage of schools that received these products. Parsley, for instance, was delivered in 93%–95% of the schools. The out-degree allows us to map the movement of vegetables to schools.

The in-degree metric corresponds to the number of food types consumed by the various schools, as shown in Table 2.

Table 2. In-degree

in degree	schools	normalised in degree
13	17	8,4%
12	5	2,5%
11	97	48,0%
10	86	42,6%
7	3	1,5%

Analysing the in-degree metrics, we observed that only 8.4% of the schools received thirteen types of vegetables in 2017. Around 92% of them received ten or 11 types of products.

4.3 Betweenness centrality

Having established the degree centrality analysis, we studied the betweenness centrality, as shown in Table 3.

Table 3. Betweenness

Food type	*betweenness*	*Normalised betweenness*
Savoy	113.311	0.240
Chard	113.311	0.240
Lettuce	113.311	0.240
Escarole	45.978	0.097
Carrot	45.735	0.097
Chives	45.578	0.096
Parsley	45.578	0.096
Cauliflowers	23.973	0.051
Beetroot	18.746	0.040
Zucchini	10.282	0.022
Chayote	10.282	0.022
Cabbage	10.046	0.021

Cress	9.871	0.021

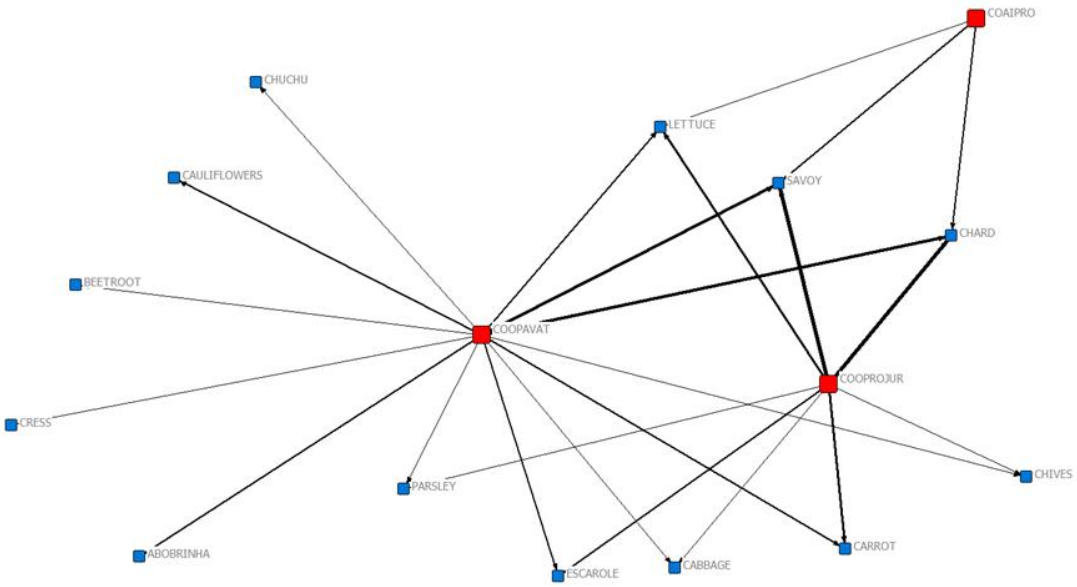
Our results here confirm that chard, lettuce and savoy are central in this supply chain and that they are the main products sent to the schools. Betweenness centrality in a social network serves to identify the ability of a node to act as an intermediary in a relationship. In our case, it allows us to establish that these three main products are present in the entire distribution process. Thus, the logistics operation needs to consider these products as obligatory.

4.4 Strength of relationship

After establishing the types of items bought for each school, we sought to identify the volume produced by each family farm cooperative. We divided these into two networks: weight and units.

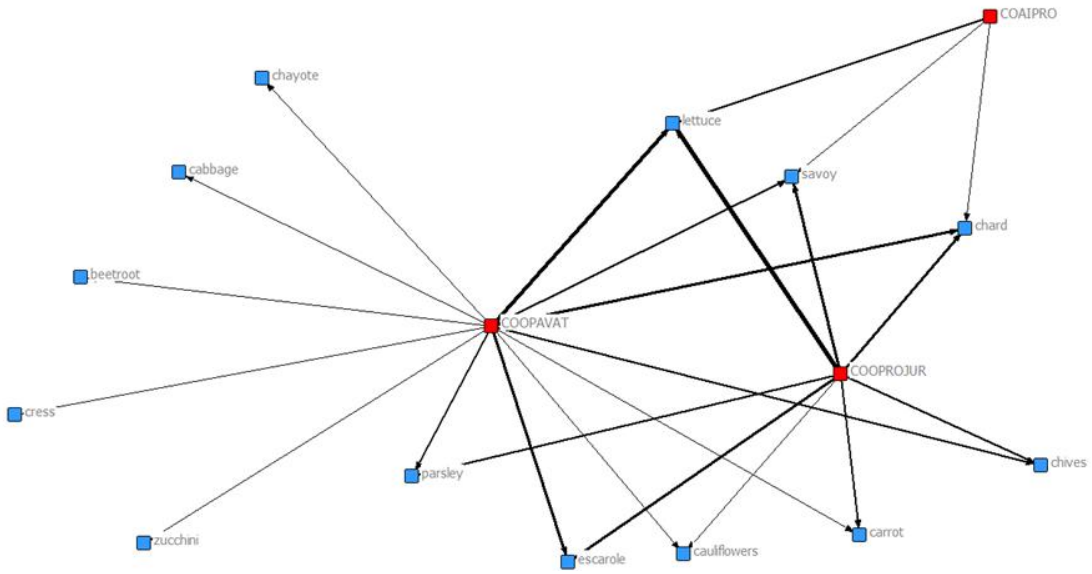
A visualization of the weighted networks in which cooperatives and vegetables are nodes, and ties represent each vegetable delivered by the various cooperatives, are shown in Fig. 3.

Figure 3. Cooperatives – vegetable-weighted (kg) network



In Fig. 3, the weights are the amount in kilograms of the various food types delivered by the cooperatives. In Fig. 4, the weights are the numbers of packages of vegetables delivered by the cooperatives.

Figure 4. Cooperatives – vegetable-weighted (units) network.



Figures 3 and 4 show the weightings in various networks. The nodes are three cooperatives (red squares) and 13 vegetables (blue squares). The ties are the supply flows of each vegetable from various organizations. The widths of the ties represent the weights.

In case of Fig. 3, the weights are the amount in kilograms. Chard, lettuce and savoy are the only food types supplied by the three cooperatives. The amounts in kilograms are greater compared with the others. We identify the greater quantities through the larger widths of the ties.

Beetroot, cauliflower, chayote, cress and zucchini are the food types provided only by the COOPVAT cooperative. There may be a scale gain if they were supplied by the other two cooperatives because they are already consumed and there may be opportunities for new producers to join the school feeding programme.

Carrots, cabbage, chives, escarole and parsley are the vegetables supplied by two cooperatives, but in smaller quantities (kg). There may be a potential for scale gain for these items, especially for cabbage, which is similar to lettuce in volume.

Of the food types provided only by the COOPROJUR cooperative, beetroot, chayote and cress are the items supplied in smaller quantities (kg). There may be a potential to increase the amount of these items provided if other cooperatives and other producers provide them.

In Fig. 4, the weighting is the number of packages. Lettuce earns relevance compared with the network weighted in kilograms. This fact can represent greater packaging, transport and handling efforts. Besides, lettuce can occupy a greater storage area.

Carrots, cauliflower, chard, savoy and zucchini lose importance compared with the network weighted in kilograms. As these items possibly occupy less space, there is a potential for the better use of vehicle capacities, combining loads with lower volume food types.

5. Discussion and Conclusions

The findings showed that schools adopted a non-standardized menu of vegetables. Beetroot, carrots, chard, chives, escarole, lettuce, parsley and savoy were the eight products that schools ordered the most. However, there was a striking difference among their production volumes, as shown in Figs. 3 and 4. This situation by far affected logistics operations in which the ideal was a pattern in consumer habits and quantities distributed that obtained scale gains.

Another interesting aspect related to beetroot, carrots, chard, chives, escarole, lettuce, parsley and savoy is their highest out-degree centrality, between 93.02% and 93.95% of schools. This result indicated that all logistics operations need to be able to deal with these products, as mentioned earlier. Nonetheless, when we also considered betweenness centrality, only chard, lettuce and savoy presented the highest centrality, which demonstrated that they were the only products that the three cooperatives distributed, indicating that these need to be the main focus of distribution logistics.

Producers of cauliflower, chayote, cress and zucchini may have had less power or influence than those producing other products in the network. A smaller number of schools consumed these items, and this could be an indication to review production or motivate nutritionists to adopt these vegetables in their menus.

These above results lead us to conclude that it is difficult to standardize distribution once each school establishes a different menu and that it is challenging to organize distribution logistics because of the complexity of linking schools' demand with family farm production.

It is worth highlighting that family farms usually plant what they think is appropriate to their business and then offer it to the municipalities. These products need to be bought by the State, which, from the producers' point of view, has an obligation to support local production. For this reason, they often delivery products in non-standardized measures.

It is crucial to point out that vegetables are different from fast-food from the point of view of acceptance by students. Even when a nutritionist adopts all kinds of vegetables in their menu, some students merely avoid them. This behaviour could simply increase food waste instead of reducing malnutrition.

Also, in a similar way, meals are directly affected by chefs' skills. The acceptance of a meal can be low in the case of unappetizing food. We agree that vegetables are fundamental to achieving food security and avoiding malnutrition, but it is unlikely that schools can force their students to consume all of the products.

As far as the food supply chain and logistics are concerned, there is no doubt that the main aspects of short supply chains such as micro-scale businesses (Migliore et al., 2014), trust between consumers and producers (Aggestam, Fleiß and Posch, 2017), social, economic and

environmental values (Jarosz, 2011), and transport runs for producers (Bloom and Hinrichs, 2011) are present in this case. The main challenge from a supply chain management perspective will be to build trusting relationships among producers, government, schools and transport operators. Moreover, it will be essential to create a pattern for goods and distribution procedures as well as compensation for long distribution routes.

SNA was used to organize the information and identify the main challenges surrounding food distribution from family farms to schools within the scope of the Brazilian School Feeding Programme. The causes are there, but it is difficult to identify them without the basic analysis obtained through the use of SNA. SNA considers all of the actors in a supply chain to determine which ones are most relevant to the performance of the entire network.

By exploiting computer tools, SNA can produce systematic outputs, bringing out network actors' behaviour and allowing us to reach a more wide-ranging and organized view of network aspects (Carter, Ellram and Tate, 2007).

This article is part of ongoing research that intends to improve the distribution of vegetables produced on family farms to schools. Mogi das Cruzes was selected to participate in the project and gather the various characteristics of distribution in urban and rural areas.

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4.5 Artigo IV

O artigo *Understanding Challenges in Food Distribution for School Feeding Programmes: family farming outlook in Mogi Das Cruzes city, Brazil* está em revisão final e será submetido para periódico qualificado.

A motivação para a adoção do método AHP foi a identificação de diferentes visões e opiniões a respeito da operação logística do PNAE em Mogi das Cruzes. Como as opiniões se mostraram amplas e divergentes, o método AHP foi considerado como um meio de integrar os julgamentos dos principais atores da cadeia de suprimentos numa análise multicritério, com proposição de alternativas de melhoria da operação logística.

A árvore de critérios e alternativas foi elaborada e validada junto aos membros da Secretaria da Agricultura e especialistas da área de agronegócio e engenharia de produção que colaboraram com a pesquisa. A partir da árvore validada, o questionário de julgamento em pares foi definido (Apêndice B - Questionário AHP).

Em dois momentos ocorreram eventos promovidos pelo governo local, em que se reuniram os produtores ativos no PNAE e os responsáveis pela alimentação nas escolas da rede. Nas duas ocasiões, foi possível aplicar o questionário AHP sob o consentimento das Secretarias da Agricultura e da Educação.

O método multicritério permitiu consolidar as opiniões de produtores familiares, escolas da rede pública, operador logístico do sistema e de membros do governo local.

Manuscript (without any authors' details)

Understanding Challenges in Food Distribution for School Feeding Programmes: family farming outlook in Mogi das Cruzes city, Brazil.

Abstract

Many countries are facing malnutrition using school food programs to offer free meals for students and teach them how to eat adequately. Brazil, for instance, adopted a National School Feeding Program that attends more than 5,000 municipalities. This program beyond face malnutrition seeks to empower family farming acquiring fruits and vegetables directly of these small farms. The purpose of this paper is to study the factors that impact on logistics distribution of vegetables provide by family farms to schools through Brazilian Program of School Feeding using as reference the city of Mogi das Cruzes. We adopted the Analytic Hierarchy Process, a multicriteria decision method for the study. We collected the opinions of three groups involved: family producers, schools, and specialists, and a decision tree was made with a set of criteria and alternatives that affect logistics distribution. The results showed that the criteria outbound logistics that include storage, route definition, handling and packing is the most crucial to logistics distribution. Moreover, the best alternative to improve the city distribution is to create a new cross-docking point capable of reduce routes, improve quality control and fed-cut processing vegetables.

Keywords: Family farms, Short Food Supply Chains, Analytic Hierarchy Process, School Feeding

Paper Type: Research paper.

1. Introduction

Brazil is a of the world's leading food producers. Brazilian agriculture has experienced significant growth in the last four decades (Chaddad, 2016). In 2006 there were 5,175,489 farms of all types in Brazil. Only the family farming had 4,367,902 establishments in that year, representing almost 85% of the total of farms (Froehlich, Melo, & Sampaio, 2018). The family farming model discards large-scale agricultural manufacture and encourages alternative economies and arrangements of development through diversification (Córdoba, Selfa, Abrams, & Sombra, 2018).

One important way to empower family farming is the Programa Nacional de Alimentação Escolar (Brazilian National School Feeding Program – PNAE), that transfers resources for the purchase

of food from family farming to be destined for school meals. Brazil has 5570 municipalities (IBGE, 2017). The program attended in 2016, 5333 municipalities (FNDE, 2018b). More than 40 million students had meals purchased with PNAE resources (FNDE, 2018c).

School meals (Belot & James, 2011; Christel & Michael, 2005; Condon, Crepinsek, & Fox, 2009; França et al., 2018; Taras, 2005) and school feeding programs (Carnevalli, 2017; Chauhan, 2015; Jomaa, McDonnell, & Probart, 2011; Kristjansson et al., 2016; López-Olmedo et al., 2018; McEwan, 2013; Nogueira et al., 2016) have been attracting interest of researchers. Despite of that, we know surprisingly little about their causal impact on education outcomes, especially academic achievement (McEwan, 2013).

Using governmental resources for the direct buy of food from family farmers for school meals creates a Short Food Supply Chain (SFSC). These Supply Chains are essential for developing social and economically the local communities and approaching producers and consumers (Beckie, Kennedy, & Wittman, 2012). The existence of informal intermediaries which prevent direct contact between farmers and retailers, are regarded as important ‘‘supply chain barriers”. Reducing these barriers has been an important food policy issue (Aysoy, Kirli, & Tumen, 2015).

On the other hand, Food Supply Chains (FSCs) in developing countries need to be supported by encouraging small farmers to organize and to diversify and upscale their production and marketing. Investments in infrastructure, transportation, food industries and packaging industries are also required. The public and private sectors have a role to play in achieving this (Gustavsson, Cederberg, & Sonesson, 2011).

The inadequacies of Food Supply Chains (FSCs) should be reduced to assurance food security for a growing world population and the planned restructure of FSCs can contribute to meet these challenges. Nevertheless, defining the optimal FSCs arrangement is a complex matter (Jonkman, Barbosa-Póvoa, & Bloemhof, 2018).

The poor qualification of farmers, a small level of integration between producers, municipalities, logistics services providers and schools, and lack of knowledge of legal aspects of the school feeding program are noted in SFSCs (Lopes & Diniz, 2018). These issues combined with problems as the poor quality of roads, disabilities and vehicles can make the logistics operation a crucial matter.

Development of multi-criteria decision making (MCDM) researches accelerated during the 80s and early 90s, and seems to have continued its rapid growth (Erdogan, Šaparauskas, & Turskis, 2017). Studies provided relevant information about the Analytic Hierarchy Process (AHP) as a useful method for complex and multi-criteria scenarios (Dong & Cooper, 2016; Erdogan et al., 2017; Gerdsri & Kocaoglu, 2007, 2007; Ozdemir & Sahin, 2018; Pedrycz & Song, 2014).

The adoption of multi-criteria decision methods as the AHP (Saaty, 1980) can help those involved to improve logistical operations in Short Food Supply Chains. The literature reveals a gap in the contributions made by studies on these issues.

Mogi das Cruzes is considered a very important food producer city in Brazil. Using resources of the Programa Nacional de Alimentação Escolar (PNAE – National School Feeding Programme), this Short Food Supply Chain is integrated by 209 schools located at the city´s area that are supplied by 58 local producers accessed by the municipal government.

The objective of this research is to evaluate the factors that impact in the logistics operation of the Programa Nacional de Alimentação Escolar in Mogi Das Cruzes city, Brazil, considering the

Short Food Supply Chain where the ties are family producers, the municipality, a logistics service provider and schools, by using the Analytic Hierarchy Process–AHP (Saaty, 1980). Our findings can help decision makers in Brazil with similar SFSCs and logistics issues, as the PNAE transfers resources for a high number of Brazilian municipalities.

The overall structure of the study takes the form of the following sections: introduction is presented first, literature review, a methodological approach that brings information about the AHP method, AHP application and analysis, and conclusions.

2. Literature review

2.1. Food Supply Chains (FSC) and Short Food Supply Chains (SFSC)

Food Supply Chain (FSC) management has been attracting increasing attention from the academics and the practitioners. Much effort has been made to improve the living standard. Though, problems such as high chain cost, food waste, food losses and environmental matters still occur (Li, Chu, Yang, & Calvo, 2016).

Many types of food are highly perishable and fragile. The added value is low and therefore the transport must be efficient with the lowest possible cost. Cross-docking is increasingly used to reduce inventory holding and the time products spend in the supply chain. It is especially suitable for fresh produce distribution with a short shelf-life (Agustina, Lee, & Piplani, 2014).

A Food Supply Chain (FSC) that involves direct purchases of local food from familiar farmers with smaller distances between the production and consumption is known as a Short Food Supply Chain (SFSC). They contain the idea of local food, which means distinguishing product features, natural raw materials and methods, and direct incomes for families (Sage, 2003). Short Food Supply Chains have experienced important developments for unevenly a decade, encouraging the interest of producers, consumers and governments (Mundler & Laughrea, 2016).

Developing alternative food chains as box schemes, direct market and producers' stores, generates forms of close relationships between producers and consumers through a niche market expected to be better profitable (compared to long supply chains). Supplying cities via Short Food Supply Chains may be a way of maintaining and promoting local agriculture (Aubry & Kebir, 2013). The embeddedness between producers and consumers has been one of the factors that have ensured the survival of farmers' markets as one of the main Short Food Supply Chains (SFSC) for agricultural producers (Oñederra-Aramendi, Begiristain-Zubillaga, & Malagón-Zaldua, 2018).

This new localization of food can provide opportunities to build new links between diverse actors in the value chain and reinforce existing ones, establishing tighter relationships between production and production locations (Beckie et al., 2012).

Researchers have been discussed the social responsibility in the agriculture sector. Using the land, the role of tradition and defense of nature and environment are closer to this matter. Social environmental have turned into a vital part of the agricultural policy's objectives. In this context, there is a growing interest by the consumers towards the Short Food Supply Chain (Bisogno,

2016) , which provides the renewal of the direct relations between producers and consumers (Bisogno, 2016; Kirwan, 2004).

Globalization has led consumers to switch their consumption behavior from a local production style to super-and-hypermarkets. This is a result of mass production and consumption, enabled by the global sourcing processes that tend to reduce final product prices (Falguieres et al., 2015; Giampietri, Verneau, Del Giudice, Carfora, & Finco, 2018; Oñederra-Aramendi et al., 2018; Sonnino & Marsden, 2006). The concept of SFSCs has emerged as a reply by concerned consumers to the predominant traditional global markets, defined by standardized production, anonymous industrialized food, long food miles and the uneven power along the food supply chain (Giampietri et al., 2018).

Reducing distances between production and consumption include a inclination to participate in producing and distributing food according to horizontal relationships and ethical values (Hinrichs, 2003). Direct marketing strategies have been recognized as a viable business option for familiar farmers, as they allow them to obtain a better price by retailing products straight to customers (Uematsu & Mishra, 2011).

Family farmers obtain both economic advantages and social benefits. SFSCs bring economic benefits because they allow better value added and reduces the farmers' market risks, through a decrease in the quantity of intermediaries, through a higher range of products and consumers, and through improved control of prices (Richard, Chevallier, Dellier, & Lagarde, 2014; Uematsu & Mishra, 2011). The social matters include professional reintegration for vulnerable or marginalized farmers (Chiffoleau & Prevost, 2012), expansion of opportunities to small farmers, and promotion of women's professional ascension, contrasting large scale agriculture (Trauger, Sachs, Barbercheck, Brasier, & Kiernan, 2010).

The following typology (Fig. 1.) differentiates SFSCs according to the arrangements of proximity between producers and consumers (Aubry & Kebir, 2013).

table 1 - Types of SFSC (adapted from Aubry & Kebir, 2016)

	Geographical proximity	Selling	Relations
Case I	weak	direct online	distance
Case II	strong	local supermarkets and local professionals	indirect
Case III	strong	farmer's markets and on-farm's	direct

The first case does not indicate near localization of producers and consumers. The proposition here is neither to consume nor to sell locally, but the closeness in terms of quality, pleasant interface and particularity of foods. Case II is a type of SFSC with geographical proximity, without a direct relationship between producers and consumers. And case III is the complete understanding of SFSC, combining geographical and organizational proximity with classical forms of direct business. The relationships are the deepest since the producer contacts the consumer (Aubry & Kebir, 2013).

Confidence in changing consumer food preference and acquisition decisions seems to be progressively significant today (Grebitus, Steiner, & Veeman, 2015). Trust, towards food producers (instead of retailers), is a complex concept that plays a crucial part in decision-making when the information is limited or complicated to assess, as for the food acquisition.

(Ding, Veeman, & Adamowicz, 2015) . Therefore, customer trust can play a key role in solving this problem, especially in the case of SFSCs (Giampietri et al., 2018).

2.2. School feeding programmes and the Brazilian School Feeding Programme

Nutritional deficits in school-aged children have a strong impact on their intellectual and behavioral development. Children feeding has been seen in studies conducted in different countries (Azeredo et al., 2015; Cabrera-Vique et al., 2015; Condon et al., 2009; França et al., 2018; Glewwe, 2005; Shin, Lee, Shin, & Shin, 2014; Taras, 2005).

Short-term attention and memory are negatively influenced by skipping breakfast (Christel & Michael, 2005). Improving the quality of schools meals raises test scores and reduces absences (Belot & James, 2011). School meals may induce families to enroll their children in school, to enroll their children sooner, or, conditional on enrollment, to encourage regular attendance (McEwan, 2013).

School feeding programs are widespread (Kristjansson et al., 2016). Governments and development organizations dedicate considerable resources for providing free school meals to poor children, in both less-developed and richer countries (McEwan, 2013).

School feeding programmes have been gaining popularity in developing countries, mostly among those affected severely by childhood hunger and malnourishment. These programs aim to enhance the concentration span and learning capacity of school children by providing meals to reduce short-term hunger that may otherwise impair children's performance (Jomaa et al., 2011).

Federal government published the Brazilian Federal Law 11.947 that created the Programa Nacional de Alimentação Escolar (PNAE) in 2009, that sets a minimum of 30 percent of the purchase of food comes from the family farming (Carnevalli, 2017; MINISTÉRIO DA EDUCAÇÃO, 2018). Municipalities can provide school meals by complying with the legal obligation of using 30% of the financial resources provided by Fundo Nacional de Desenvolvimento Escolar (FNDE) for the purchase of family farm products (Nogueira et al., 2016).

The Fundo Nacional para o Desenvolvimento Escolar (National Fund for the Development of Education - FNDE) is a federal department linked to the Brazilian Ministry of Education. It is responsible for providing technical and financial assistance to states and municipalities, through legal resources transfers of PNAE (MINISTÉRIO DA EDUCAÇÃO, 2018).

The Brazilian National School Feeding Programme (PNAE) provides school meals to students of the basic education level, attracting students to schools and reducing absenteeism taxes, improving school progression rates (Nogueira et al., 2016).

PNAE constitutes a set of activities that pursue the access and permanence of poor students in higher education and it should consider the necessity to encourage equality of opportunities, contribute for an improvement of academic performance and act, preventively, in the situations of retention and drop outs arising from insufficient financial conditions (Borsato & Alves, 2015).

The National School Feeding Programme (PNAE) is a globally recognized policy, being a reference for deployment of sustainable school feeding programs. Advances that have taken place bring better learning and perpetuity conditions of the students at the school (Silva, Amparo-Santos, & Soares, 2018).

School feeding programs emerges, among other actions, the guarantee of the supply of meals produced from the principles of healthy eating, valuing regional customs and the use of food from family farming. By the creation of school feeding boards, the program enables society to participate in the PNAE policy (Silva et al., 2018).

The two largest Brazilian cities, São Paulo and Rio de Janeiro, received in 2018, BRL 95.895.624,60 and BRL 67.456.802,24. The City of Mogi das Cruzes received BRL 6.827.172,00 in 2018 (FNDE, 2018a). At least 30% of this value was destined for food purchases from family farming.

The school feeding programme attended 41 million basic education students with an investment of BRL 3.90 billion in 2017. When compared to 2016, there was an increase of 10.8% in investments (MINISTÉRIO DA EDUCAÇÃO, 2018).

Law No. 11,947 was important for the Brazilian rural development. The law has strengthened practices that reconnect the vital necessities of feeding to productive processes, to the dynamics of "nature", to cultural constructions and to local social identities, and the proximity between producers and consumers (Lopes & Diniz, 2018).

The report of the programme Boas Práticas da Agricultura Familiar para a Alimentação Escolar (Good practices of family farming for school food), which had the financial support of Food and Agriculture Organization of the United Nations, brings aspects of logistics issues in different Brazilian cities (Lopes & Diniz, 2018) shown in table 2.

table 2 - logistics issues of the family agriculture in cities attended by PNAE

City	Population	% of the PNAE resources for Family farming (2016)	Logistics issues
Dois Irmãos	30753	71,39%	Difficulties in handling and distribution
Feliz	13273	49,7%	Insufficient contact between schools and producers generated the need of training of farmers and school staff, discussing handling, delivering and demand forecasting
Gaurama	5878	87,8%	The producers delivered the food in a single location. Food was distributed to schools, generally arriving later than expected. It was difficult to fulfill the menu
São Lourenço do Sul	43111	41,21%	The days scheduled for delivery implied the social life of the farmers or affected the quality
Mafra	52912	69,59%	There was much supply of the same products and the lack of others, because of climatic conditions, and some products were not delivered in the previously demanded amount

2.3. Multicriteria decision-making and the Analytic Hierarchy Process (AHP)

The complexity of the decisions that management face makes it difficult to depend on a single decision maker's knowledge and capabilities to obtain a meaningful and reliable solution (Dong & Cooper, 2016).

In decision-making problems, we are commonly faced with information provided by humans, which is inherently non-numeric (Pedrycz & Song, 2014). Important buildings requires solving complex decision-making problems that involve the tangible and intangible values of numerous interest groups (Chen, Chiu, & Tsai, 2018). Multicriteria decision making (MCDM) constitutes both the framework for structuring decision problems, as well as a set of methods for generating preferences among alternatives. Examples of MCDM techniques are AHP, TOPSIS, PROMETHEE and ELECTRE (Awasthi, Omrani, & Gerber, 2018). Their main benefit is the capacity to take into account contradictory, multidimensional, incommensurable and ambiguous effects of decisions (Beinat, 2001).

MCDM refers to making decisions in the occurrence of multiple conflicting criteria. Each criterion may have diverse units of measurement, quality characteristic, and relative weight. Criteria can be measured numerically and other can only be defined subjectively (Erdogan et al., 2017). In a MCDM problem, a number of alternative options are examined based upon constraints, preference and priorities of decision makers (Ozdemir & Sahin, 2018).

The multiplicity of issues concerning organizational matters in decision making requires that the managers deal with the multicriteria approaches and this practice is called multi-criteria decision making (Rabello Quadros & Nassi, 2015). The classic approach to dealing with the uncertainty of information is based on the assumption that the analysis is carried out for a given number of solution alternatives and a given number of representative combinations of initial scenario (Pereira, Ekel, Palhares, & Parreiras, 2015).

Governments can analyze problems of transportation infrastructure with a multicriteria decision making approach (Azis, 1990; Castro-Nuño & Arévalo-Quijada, 2018; Tudela, Akiki, & Cisternas, 2006).

Given a finite number of alternatives to be considered in a certain scenario, the objective is to order them by associating with them some degrees of preference expressed in the [0,1] interval. The essence of the method introduced by Saaty is to determine such preference values through running a series of pairwise comparisons of the alternatives (Pedrycz & Song, 2014).

The Analytic Hierarchy Process (AHP), which is a comprehensive tool for constructing decision models and establishing the decision priorities with respect to a finite set of alternatives, has been widely applied to group decisions because of the flexible structure and our innate ability to make relative comparisons (Dong & Cooper, 2016). The AHP method introduced by (Saaty, 1980) depends on a series of pairwise comparisons considering the perception and evaluation of decision makers. AHP is easy to use due to its hierarchical structure and pairwise comparison allow users to give different weight for each criterion (Ozdemir & Sahin, 2018).

The first step of AHP is to decompose the problem into different levels within a hierarchy, in which the highest level represents the overall goal of a decision-maker, the second level corresponds to the multiple criteria considered for assessment and the bottom level corresponds to the alternatives being evaluated (Promentilla, Aviso, Lucas, Razon, & Tan, 2018).

3. Multicriteria analysis and the AHP method

Multicriteria decision-making (MCDM) techniques like the AHP method are useful procedures to apply when there are multiple criteria to take into account and it is necessary to prioritize them in a project management background (Gogas, Papoutsis, & Nathanail, 2014). The analytical hierarchy process (AHP) is a flexible approach that allows subjective factors to be considered in risk analysis. It integrates multi-criteria decision-making methodology with both quantitative and qualitative criteria (Gerdsri & Kocaoglu, 2007).

The strategic methodology is based on the use of the AHP multi-decision-making method. This method is useful for prioritization of different range of alternatives given different criteria, obtained from a previous discussion (Prieto, 2016).

Researchers have been applying the AHP method in the decision-making process that involves logistics issues (Gürcan, Yazıcı, Beyca, Arslan, & Eldemir, 2016; Peng, 2012; Shaik & Abdul-Kader, 2018; Sirisawat & Kiatcharoenpol, 2018; Zhao et al., 2018). Also, author have been applying AHP supported by the Expert Choice software (Chandio, Matori, Yusof, Talpur, & Aminu, 2014; Dobias, 1990; Dönmez, 2013; Erdogan et al., 2017; González G, 2015; Melón, Aragonés Beltran, & Carmen González Cruz, 2008; Rodríguez-Padial, Marín, & Domingo, 2015; Williams, Dennis, Stam, & Aronson, 2007; Yin, 2013; Yunus, Samadi, Yusop, & Omar, 2013).

The AHP method presents several applications for the regional transportation and for the urban transportation, especially for the planning problems, and particularly with significant studies aiming at analysis for Brazil (Rabello Quadros & Nassi, 2015). AHP models have also been used to construct scenarios to evaluate risks that may occur during logistics operations (Lam, Choy, Ho, Cheng, & Lee, 2015).

The AHP method seeks to identify and give weights to multiple-criteria of selection, considering existing alternatives. It still incorporates objective and subjective evaluation measures and allows testing its consistency (Saaty, 1980). The applicability of the AHP method starts building a decision tree (DT) that deploys the main objective hierarchically. It is important that the hierarchy should be clearly constructed because different complexities of the hierarchy result in different rankings (Ishizaka & Labib, 2011). The multiple components that arise are compared in pairs. Then, the priorities are arranged.

The pairwise comparison procedure uses a ratio scale (Harker & Vargas, 1990). The scale recommended by (Saaty, 1980) range from 1 to 9 with 1 meaning the indifference of importance of a criterion in relation to the other, and 9 meaning the extreme importance of a criterion over another (Saaty, 2008; Vidal Vieira, Ramos Toso, da Silva, & Cabral Ribeiro, 2017). The AHP method is based on pair comparisons, arranged in a square matrix $n\ x\ n$, where the lines and columns correspond to the criteria investigated for the problematic in examination (Rabello Quadros & Nassi, 2015):

$$A = \left[\propto_{ij}\right] n\ x\ n$$

where lines $i \epsilon n$ provide the ratios between the index criteria weight i, in relation to the other $j \epsilon n$, being $n = \{1, 2, \dots, n\}$. Consequently, $\propto_{ij}$ corresponds to the weight rate assumed by an expert, comparing the criteria of line i with the criteria in the columns j on the matrix A. The matrix A is such that $\propto_{ij} = \frac{1}{\propto_{ji}}$ and positive, and $\propto_{ij} = 1$ when $i = j$. For instance, if i is 3 times more important than j, so j is $1/3$ times more important than i.

In the AHP process, decision makers are required to make more comparisons than are needed to establish a set of weights for criteria and for alternatives (Vidal Vieira et al., 2017). Numeric values are derived from the subjective preferences of individuals, and therefore, it is impossible to avoid inconsistencies in the final judgments. The question is how much inconsistency is acceptable (Mu & Pereyra-Rojas, 2017).

This is considered a suitable practice because the decision maker can reflect on any inconsistencies in the judgements by checking the criteria automatically on one level independent of another level (Goodwin & Wright, 2014). When several pairwise comparisons are achieved, inconsistencies may arise (Saaty, 1980). For instance, the criteria k is slightly more important than the criteria g, while the criteria g is slightly more important than the criteria f. An evident inconsistency arises if the decision maker estimates that, the criterion f is similarly or more important than the criteria k.

The index of consistency of a pairwise matrix shows the distance between the maximum eigenvalue λ_{max} of A and the maximum expected index. The theoretic rate of max λ is n, and this represents the number of defined criteria and, so, its deviation is given by $(\lambda_{max} - n)$. Being max λ the maximum eigenvalue of A, w is the eigenvector of A such that the same corresponds to the vector of priorities (Rabello Quadros & Nassi, 2015).

The vector *w* must be defined in the expression (Saaty, 1980):

$$A_w = \lambda_{max} W$$

Supposing consistent decision maker, w_i, $\forall\ i\ \in N$ is found by the nontrivial solution of (Rabello Quadros & Nassi, 2015; Saaty, 1990):

$$Aw = nw$$

Supposing a not-perfectly consistent decision maker, a vector of values must be found that meets the following expression (Rabello Quadros & Nassi, 2015):

$$\lambda_{max} = \frac{1}{n} \sum_{i \in N} V_i \ \frac{Aw_i}{w_i}$$

Therefore, λ_{max} permits to inspect the nearness of the obtained scouring with the scale of ratios that would be used if the matrix A was totally consistent. This can be done through the calculation of an index of consistency (IC) and the ratio of consistency (RC). The index of consistency is calculated by (Dong & Cooper, 2016; Mu & Pereyra-Rojas, 2017; Pedrycz & Song, 2014; Rabello Quadros & Nassi, 2015; Saaty, 1980):

$$IC = \frac{\lambda_{max} - n}{n-1}$$

A random matrix is one where the judgments have been entered randomly and therefore it is expected to be highly inconsistent (Mu & Pereyra-Rojas, 2017). The index of random consistency (IR) is obtained from Table 1, according to the number of criteria n (Dong & Cooper, 2016; Mu & Pereyra-Rojas, 2016, 2017; Rabello Quadros & Nassi, 2015; Saaty, 1990).

table 3- Index of random consistency

n	1	2	3	4	5	6	7	8	9	10
IR	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The ratio of consistency (RC) is calculated by (Dong & Cooper, 2016; Saaty, 1980):

$$RC = \frac{IC}{IR}$$

For the assessment, the higher the RC, the higher the inconsistency. The judgments matrix is reasonably consistent if the ratio is lower than 10% (Mu & Pereyra-Rojas, 2017; Rabello Quadros & Nassi, 2015).

3.1. Criteria and alternatives: the decision tree of AHP

Definition of criteria and alternatives to evaluate the factors that impact in the school feeding program logistics were obtained in a meeting with agribusiness, academic and governmental actors (table 2).

table 4- definition of criteria and alternatives – group of specialists

Origin	**Institution**	**Expertise/professional**
Governmental (2)	Secretaria da Agricultura de Mogi das Cruzes city	Secretary of Agriculture / Agricultural Engineer (1)
	Secretaria da Agricultura de Mogi das Cruzes city	Advisor to the Secretary of Agriculture / Agricultural Engineer (1)
Academic (3)	Faculdade de Tecnologia de Mogi das Cruzes (public collge)	Managing Director and Agriculture course coordinator (1)
	Faculdade de Tecnologia da Zona Leste (public college)	Agribusiness logistics specialist (1)
	Faculdade de Tecnologia da Zona Leste	Operations research specialist (1)
Cooperatives (1)	COOPVAT (cooperative in charge of receiving, storing and transporting)	Cooperative's president

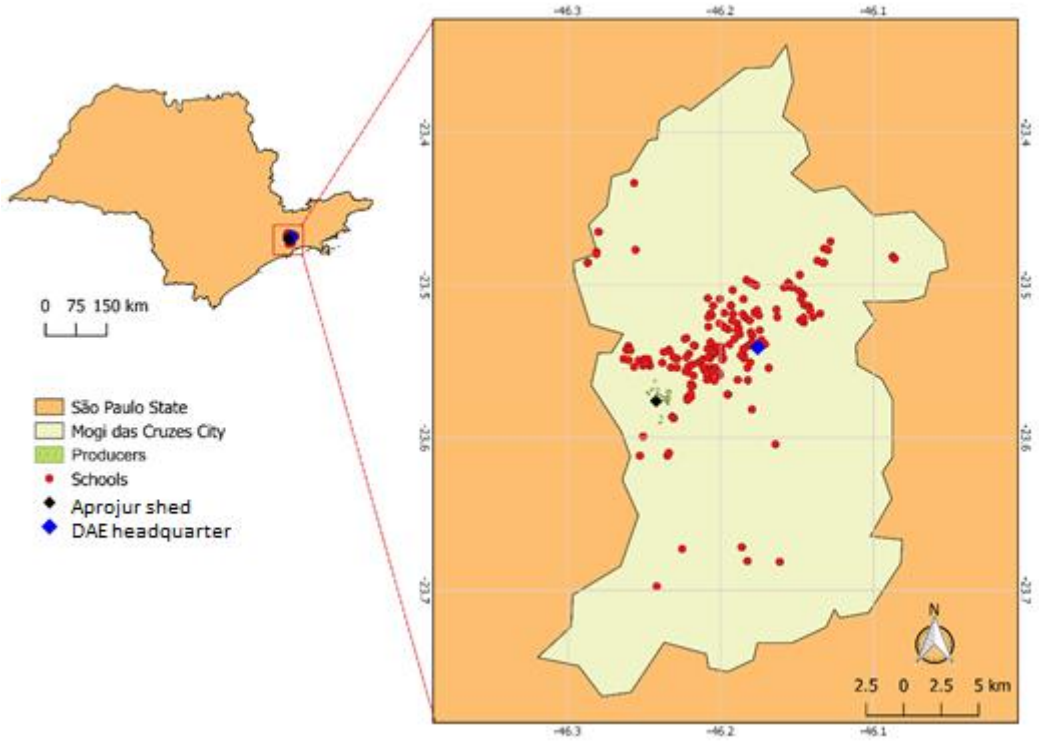
The building of the decision tree that can improve the school feeding program, by the specialists' point of view, considered five main criteria and the sub-criteria as follow:

- School's logistics inbound: related to the logistics operation in schools, considering the labor qualification, internal transport, and quality and quantity control. The sub criteria are handling, orders to the school feeding department and the storage capacity and equipment
- Family producers and cooperatives: related to food production's operations and the role of the cooperatives involved in the school feeding program. The sub criteria are the demand management and forecasting, the school level of producers and the interest in supplying for the school feeding program

- Outbound logistics: related to transportation system where the school feeding program is inserted, considering cargo traffic, vehicles, routes, and logistics activities in the shed of the Family Producers Association's (Associação dos Produtores Rurais de Jundiapeda – APROJUR). The sub criteria are storing in APROJUR, routes and handling/packing
- Municipality: related to the assignments of the secretariats of Education and agriculture, that are the sub criteria of municipality
- School Feeding Department (Departamento de Alimentação Escolar - DAE): The school feeding department purchases, stores and distributes food in schools. The headquarter is in a central urban area, near a high amount of schools. The sub-criteria are schools' management and legal aspects.

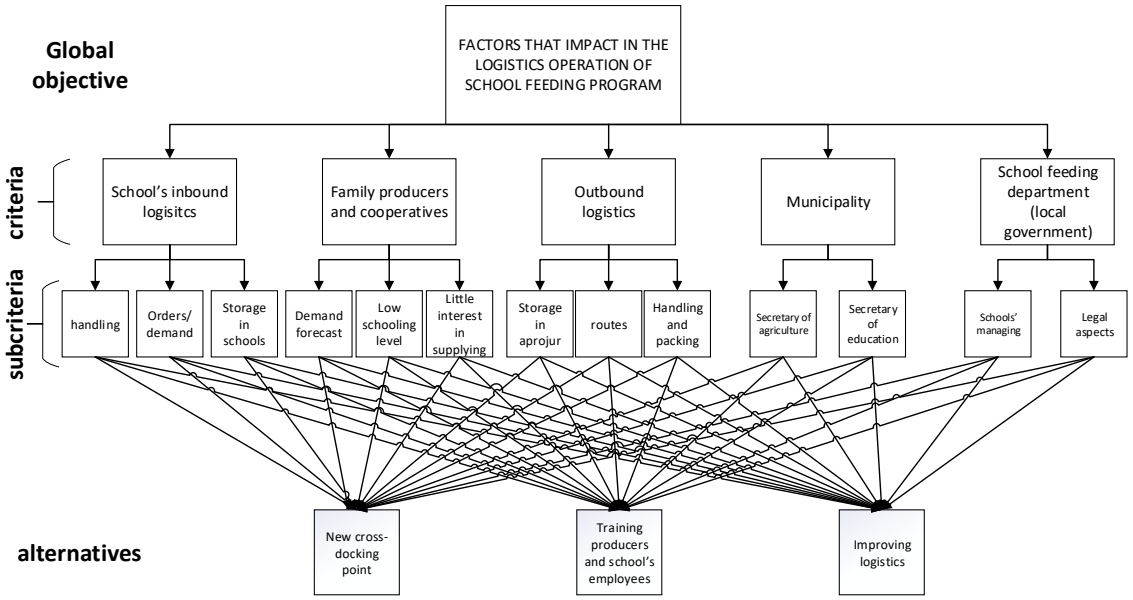
Three alternatives were proposed by the specialists to improve logistics of the school feeding program. The first is transferring all food from the APROJUR's shed to DAE headquarter, creating a new cross-docking point (fig 1), before delivering to schools. The second is training the actors, as producers, schools` managers and municipality team. The third is improving the logistics operation, including transport, packing, handling, storing, demand management and routing.

Figure 1 - proposal of a new cross-docking point in DAE headquarter



In the AHP method, the criteria and alternatives are elements of the hierarchical structure of the analysis. The decision tree is shown in figure 1.

Figure 2 - Decision tree



4. AHP application and analysis

The gathering of choices of criteria and alternatives compared in pairs and their degree of importance was obtained collecting the judgments of three groups: specialists, schools and family producers.

The employees of all schools in the network involved with school feeding were assembled for training given by the Secretariat of Education. The family producers were also gathered for training in another place, where the Secretariat of Agriculture discussed topics related to family farming. In both events, we collected the judgments necessary for the application of the AHP method. In both cases, all doubts regarding the questionnaire were elucidated by the researchers immediately. It was also possible to explain clearly to respondents the importance and purpose of the study.

The Short Food Supply Chain has 58 family producers and 209 schools. In total, 202 schools, 45 employees and 3 specialists answered the questionnaire. The pairwise comparisons and the importance degrees judgments of criteria and alternatives were organized into a spreadsheet. To take into account the judgments of several decision-makers simultaneously, the AHP procedure is to calculate the geometric mean of each element of the weight vectors (Saaty, 1980). Table 3 shows the example of the first pair comparison between the two first criteria of decision tree "school's inbound logistics" and "family producers". The most of respondents (154) judged that "family producers" is a more important criteria if compared to "school's inbound logistics". They provided an importance degree in a ratio between 1 (equal importance of the pair of criteria) and 9 (extreme importance of family producers over the school's inbound logistics) and the geometric mean was calculated as 6,19.

table 5 - example of pairwise comparison

criteria	Respondents
schools' inbound logistics	99
family producers	154

Geometric mean of importance degree	6,19

The software Expert Choice was used to rank the criteria and alternatives. Higher weights mean more influence on the global objective, that is to evaluate the factors that impact the logistics operation of the school feeding program. Combining the answers of the three groups, schools, family producers and specialists, we comprehend a global thinking on the ranking of the criteria (Fig. 3). According to the weights defined by the three groups, the criteria with the highest priority is “outbound logistics”. Considering the alternatives presented, the highest priority was the change of the cross-docking point. However, improving the logistics operation, is slightly below. Both alternatives present very similar weights (Fig. 4).

Figure 3 - Priorities (combined)

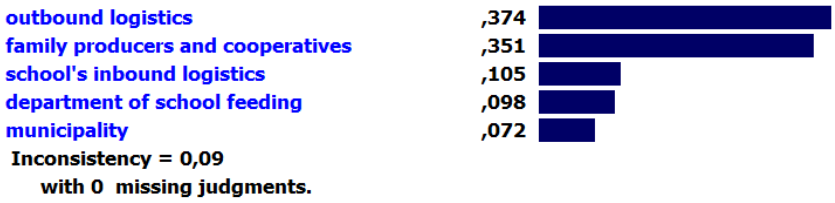
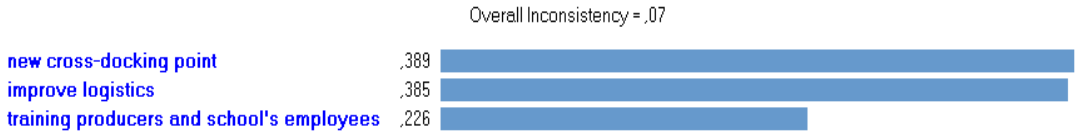


Figure 4 - priorities of alternatives (combined)



It was evaluated the judgements of the three groups, as shown in Figs. 5–7. We can realize that different groups show differences of priorities between them and when compared to figure 3.

The order of the priorities changes in the groups’ judgments. However, it is evident that the criteria “outbound logistics” has a relevant importance. This criterion is the first more important of the schools’ results, and the second more important criteria if we consider the producers1 and specialists’ results. Besides, this criterion is the most important if we consider the combination of the three groups.

Figure 5 – Schools’ criteria priorities

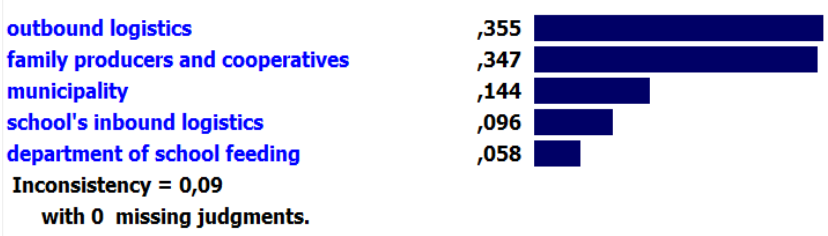


Figure 6 - Family producers' criteria priority

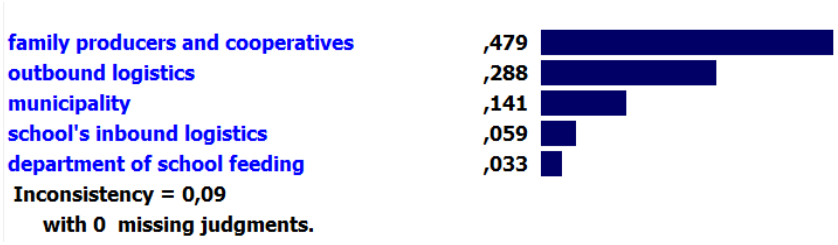
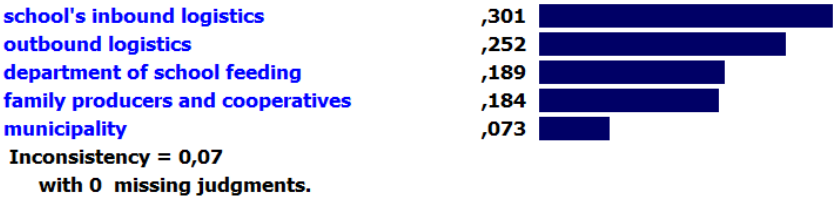


Figure 7 - Specialists' criteria priorities



The graphs of the different groups show different priorities and different behavior of weights. Schools' employees understand that family producers and cooperatives are a high-impact criterion on the global objective. The weight of this criterion is similar the most important criterion, that is "outbound logistics" (Fig. 5). As predicted, the family producers who answered the questionnaire understand that the most important criterion that impacts on the logistics of the school feeding program are the "family producers" themselves. This group also considers the "outbound logistics" to be the second most important criterion. During data collection, it was possible to realize that there is a great concern of the family producers with the high cost and the quality of the distribution operation.

The group of specialists chosen the "schools' inbound logistics" and "outbound logistics" as the two main criteria that influence the global objective. For the three different groups, both the municipality and the school feeding department are criteria of low importance for the global objective. This result is reflected in the combined priorities chart (Fig. 3), in which these two criteria appear in the last positions of importance.

In general, there is great concern about the cost of distributing the school feeding program. The perception of schools' employees, producers and the local government, that the logistic distribution costs are too high, becomes in a challenge for the program to achieve a larger scale, with the addition of new producers and new types of food. This fact was verified by the combined judgments (Fig. 3), where the "outbound logistics" is the most important criteria.

The alternatives for the improvement of the logistic operation were defined as "new cross-docking point", "training family producers and schools' employees" and "improving logistics".

The alternative to deploying a new cross-docking point came from the staff of the municipality. The new cross-docking point would be installed in the building of the current headquarters of the school feeding department (DAE). In this facility, there is the possibility of the food being inspected and eventually being minimally processed before being delivered to the schools. The

training of the people involved in the system was also considered by the specialists, due to the perception of low schooling level. Improving logistics was considered as an alternative, since those teams involved complain of various problems such as low quantities purchased, high cost of distribution, lack of storage equipment in schools, difficulties and low infrastructure for receiving and picking operations at the APROJUR headquarters, deficient packaging, and loss of food between the receiving and delivering to schools.

The following charts show the priorities of the alternatives for the improvement of the global objective of the three respondent groups (Fig. 8 – 10).

Figure 8 - Schools' alternatives priority

Figure 9 - Family producers alternatives priority

Figure 10 - Specialists' alternatives priority

The schools and producers evaluate that deploying a new cross-docking point at the school feeding department's is the alternative that will produce a greater positive impact on the global objective, among the three alternatives presented. The two groups also judge that the second alternative that most positively impacts the global objective is “improving logistics” operation as a whole. The weights assigned by the groups to the alternatives are similar.

The group of specialists considers that the best alternative would be to train the people involved. The difference between the other two groups may refer to the fact that the part of specialists is

not directly involved in the logistics operation of the supply chain. During personal contacts with those involved, the specialists declare that there is an impression that there is blindness of the whole operation, and individuals have a partial and limited view of the Short Food Supply Chain. This impression may lead to the conclusion that a large training program is needed, which was reflected in the judgments.

The AHP method allows analyzing the relative importance of each criterion and sub-criteria in the hierarchy. Each criterion was compared to the others from the same level. Each second level sub-criteria also were compared to the other sub-criteria from its own level. Table 4 shows the results of the paired comparison, with the weights of the criteria and sub-criteria. The judgments of the three different groups and their individual weights are shown (Tab. 5 – 7)

Table 6 - criteria and sub-criteria weights - combined

Criteria and weights	**subcriteria and weights**
school's inbound logistics (0,105)	handling (0,731)
	orders/demand (0,188)
	storage in schools (0,081)
family producers and cooperatives (0,351)	demand forecasting (0,674)
	low schooling level (0,101)
	low interest in supplying (0,226)
outbound logistics (0,374)	storage in APROJUR (0,681)
	routes (0,069)
	handling and packing (0,250)
municipality (0,072)	secretary of agriculture (0,167)
	secretary of education (0,833)
department of school feeding (0,098)	schools management (0,857)
	legal aspects (0,143)

Handling is a sub-criterion with the highest weight among the sub-criteria related to the school's inbound logistics criterion, which has low weight compared to the criteria “outbound logistics” and “family producers and cooperatives”. The storage in APROJUR, is the sub-criterion with the highest impact on the global objective, because it has the highest weight among all other sub-criteria and is related to the criterion “outbound logistics” that is the criterion with the highest weight of the first level of the hierarchy. The "demand forecasting" also has a high influence on the global objective, showing a high weight. It is related to the criterion "family producers and cooperatives", the second highest weight among the criteria of the first level of the hierarchy.

table 7 - criteria e sub-criteria - schools

Criteria and weights	**subcriteria and weights**
school's inbound logistics (0,096)	handling (0,707)
	orders/demand (0,223)
	storage in schools (0,070)
family producers and cooperatives (0,347)	demand forecasting (0,717)
	low schooling level (0,205)

	low interest in supplying (0,078)
outbound logistics (0,355)	storage in APROJUR (0,717) routes (0,088) handling and packing (0,195)
municipality (0,144)	secretary of agriculture (0,167) secretary of education (0,833)
department of school feeding (0,058)	schools management (0,857) legal aspects (0,143)

The judgments of the group “schools” show the sub-criteria “storage in APROJUR” and “demand forecasting” with high weights compared to the other sub-criteria. The result of this group is similar to the results of the three groups combined judgments (Tab. 4).

table 8 - criteria and sub-criteria - family producers

Criteria and weights	**subcriteria and weights**
school's inbound logistics (0,059)	handling (0,149) orders/demand (0,785) storage in schools (0,066)
family producers and cooperatives (0,479)	demand forecasting (0,710) low schooling level (0,155) low interest in supplying (0,135)
outbound logistics (0,288)	storage in APROJUR (0,160) routes (0,149) handling and packing (0,691)
municipality (0,141)	secretary of agriculture (0,875) secretary of education (0,125)
department of school feeding (0,033)	schools management (0,833) legal aspects (0,167)

The judgments of the group “family producers” show that “demand forecasting” is the most important sub-criterion. There is a concern of the family producers with the variation of the amounts acquired and lack of short and medium-term demand forecasting. There are circumstances where the amounts purchased are not delivered. The results of the judgments of this group demonstrate that the forecasting of purchases by the municipality made in partnership with the producers may represent an important option of improvements in the logistics operation.

table 9 - criteria and sub-criteria - specialists

Criteria and weights	**subcriteria and weights**
school's inbound logistics (0,301)	handling (0,528) orders/demand (0,333)

	storage in schools (0,140)
family producers and cooperatives (0,184)	demand forecasting (0,784) low schooling level (0,081) low interest in supplying (0,135)
outbound logistics (0,252)	storage in APROJUR (0,066) routes (0,785) handling and packing (0,149)
municipality (0,073)	secretary of agriculture (0,500) secretary of education (0,500)
department of school feeding (0,189)	schools management (0,250) legal aspects (0,750)

In the judgments of the group “specialists”, “handling” in APROJUR shed and inside the schools is a high-impact sub-criterion. Another sub-criterion that appears with high weight in the results is “routes”. Eight urban cargo vehicles collect food at the APROJUR’s shed and deliver to 209 schools. The Logistics Provider determines the routes. There is the thesis of the specialists that new routes can achieve shorter distances, shorter travel times and lower costs. The specialists also illustrated during the judgments that smaller vehicles could transport types of food that occupy less space. This routing study requires methods such as linear programming and discrete events simulation for the specialists interviewed. It is important to note that “demand forecasting” also presents a high weight, although the criterion “Family producers and cooperatives” has a lower weight compared to the other two groups.

Different groups show contrasting opinions about the criteria of the first level of the decision tree (table 8). “Schools” and “producers” groups attributed the highest weights for the criteria “outbound logistics” and “family producers and cooperatives”. “Schools” attributed the highest weight to “outbound logistics” and “family producers” group attributed the highest weight to themselves. “Specialists” attributed higher weight to "school’s inbound logistics” and outbound logistics. This group manifests concern about the logistics operation along the short food supply chain. This group understands the activity of the producers as a low impact activity on the logistics operation if compared to other criteria. The three groups understand that “outbound logistics” criterion has a high impact in the five’s set criteria of the first level of the decision tree. All three groups attribute low weight to the criterion “Department of School Feeding”.

Table 10 - comparison of the weights of first level criteria

criteria	Schools’ weights	Producers’ weights	Specialists’ weights
school's inbound logistics	0,096	0,059	0,301
family producers and cooperatives	0,347	0,479	0,184
outbound logistics	0,355	0,288	0,252
municipality	0,144	0,141	0,073
department of school feeding	0,058	0,033	0,189

Comparing the judgments of the sub-criteria related to each criterion of the first level of the hierarchy, they distinguish the assigned weights.

Within the “school’s inbound logistics” criterion, the “schools” group and the “specialists” group attributed the highest weight to the “handling” sub-criterion. The “producers” group attributed the highest weight to “demand and order” management. Producers estimate the food quantities requested by the schools and the purchase orders are factors of high impact on the logistic operation within the “school’s inbound logistics” criterion.

Within the “family producers and cooperatives” criterion, the three groups attributed higher weights to the “demand forecasting” sub-criterion. These judgments confirm the actors involved in the research complaining about the information flow for the entire Short Food Supply Chain.

The sub-criteria related to the “outbound logistics” criterion received the most divergent weights among the assessed criteria. Each of the three groups attributed higher weights to different sub-criteria. The group “schools” assesses that the impact of the sub-criterion “storage in APROJUR” is higher on outbound logistics than the other sub-criteria. The group “producers” attributed higher weight to the “handling and packing” sub-criterion. And the group “specialists” attributed higher impact to the sub-criterion “routes”. These divergences may represent that different groups assess that there are opportunities for improvements in different points of the outbound logistics operation.

In the criteria “municipality” and “School feeding department” which are the criteria of lower weight in the combined judgments, there are also divergences in the assigned weights. As expected, the “schools” group assesses that the education Secretariat brings more impact than the agriculture Secretariat, while the “producers” group evaluates the exact opposite. The “experts” group believes that the two departments have equal impacts on the local government’s operations in relation to the logistics operation of the chain.

Within the “school feeding department” criterion, groups “schools” and “producers” assess the sub-criterion “schools management” has a high impact on DAE activities. The group “specialists” understands legal aspects impact more than the management of the schools on DAE activities.

table 11 - subcriteria and weights of the three groups

criteria	subcriteria	schools weights	producers weights	specialists weights
school's inbound logistics	handling	0,707	0,149	0,528
	orders/demand	0,223	0,785	0,333
	storage in schools	0,07	0,066	0,14
family producers and cooperatives	demand forecasting	0,717	0,71	0,784
	low schooling level	0,205	0,155	0,081
	low interest in supplying	0,078	0,135	0,135
outbound logistics	storage in APROJUR	0,717	0,16	0,066
	routes	0,088	0,149	0,785
	handling and packing	0,195	0,691	0,149
municipality	secretary of agriculture	0,167	0,875	0,5
	secretary of education	0,833	0,125	0,5
department of school feeding	schools management	0,857	0,833	0,25
	legal aspects	0,143	0,167	0,75

5. Conclusions

Researchers have discussed school feeding programmes and multi-criteria decision methods. To contribute to these fields, this paper investigated the Short Food Supply Chain referred to the Brazilian National School Feeding Programme (PNAE) in the Mogi das Cruzes city. We applied an AHP approach to merge distinct points of view. The method has brought as a global aim, to analyze the factors that impact on the logistic operation of school feeding with food provided by family farming.

It was possible to identify relevant criteria and sub-criteria those impact on the logistics operation and alternatives that could bring improvements to the Supply Chain. We built a decision tree and collect judgments of three groups of actors. Using the Expert Choice software, we concluded “outbound logistics” is the most important criterion and a “new cross-docking point” is the best alternative.

The number of criteria and sub-criteria defined in the decision tree is large. This shows decisions regarding the logistics operation of the supply chain are complex and multi-criteria decision methods are relevant.

Analyzing the divergent judgments attributed by the three groups of respondents, schools, producers, and specialists, it is possible to conclude the supply chain can present a low level of integration, which may affect the logistics operation.

The academic contribution of this paper is consolidating the AHP method on issues involving logistical decisions. The practical contribution is to empower the multi-criteria decision making to study the logistical operations of short food supply chains.

This paper encourages similar studies in Brazilian cities that buy food from family farming for school feeding. Improvements in the logistics operation can support the National School Feeding Programme in Brazil and in countries with similar school feeding programmes.

This study has limitations. The specialists that answered the questionnaire are the same that built the decision tree. A higher number of specialists from the academia, from the logistics provider company and local government, could judge the criteria and alternatives.

This background offers valuable insights to study diverse logistics operations. Future researches may consider criteria related to costs in terms of the weight. A sensitivity analysis can be elaborated to verify changes in the ranking of alternatives by the alteration in the judgments of the criteria and sub-criteria of the different respondents.

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4.6 Artigo V

O artigo *Improvements in the Brazilian School Feeding Programme routing: a discrete event simulation approach* foi elaborado para conclusão do quadro metodológico da pesquisa e submetido em junho de 2019 para o periódico *Arena Experts*.

Esse estudo buscou melhorias no cenário atual de roteirização da distribuição de alimentos adquiridos dos agricultores familiares para as escolas da rede pública de Mogi das Cruzes. Com base nos métodos anteriores, a simulação de eventos discretos foi adotada como método principal. Uma nova clusterização das escolas foi proposta em nova análise espacial em Sistema de Informações Geográficas (GIS) e o número de rotas foi reduzido de 8 para 6.

O modelo de simulação foi montado de forma a flexibilizar a comparação de cenários. A roteirização foi comparada ao cenário proposto, analisando-se a variável "tempo de transporte"como crítica, devido à alta perecibilidade dos itens transportados.

Ao final, foi possível notar pelos resultados que houve diminuição da distância percorrida em aproximadamente 40 km, mesmo com a diminuição do número de rotas e o tempo total de transporte não foi afetado de forma relevante.

O estudo pode representar um modelo de análise de sistemas de distribuição de *Short Food Supply Chains* ligadas aos programas de alimentação escolar.

Improvements in the Brazilian School Feeding Programme routing: a discrete event simulation approach

Abstract: School feeding programmes are present in several countries and the connection of local family farming with these initiatives is a practice that brings gains to the local economy and to school indicators and promotes healthy eating for children and young people. In Brazil, the National School Feeding Programme - PNAE, stimulates the purchase of food from local family farmers. In the city of Mogi das Cruzes, 58 family producers provide fresh food for school meals for 209 public schools with financial resources of the PNAE. Despite guaranteeing regular purchases, producers complain about the high cost of distribution. This paper studies the current routing scenario of PNAE in Mogi das Cruzes city through spatial analysis and simulation of discrete events. The results proposed a new routing scenario, reducing the traveled distances with no relevant changes in transport times.

1. Introduction

Researchers recognized the importance of studies about Food Supply Chains (FSC), Short Food Supply Chains (SFSCs) and the role played by school feeding programs (Chauhan, 2015; Sonnino, Lozano Torres, & Schneider, 2014; Torres & Benn, 2017) to ensure food security during childhood and youth (Belik & Fornazier, 2017; Kristjansson et al., 2016; López-Olmedo et al., 2018).

School-age nutritional deficits bring a strong impact on behavior and intellectual development. Studies about the feeding of children in the school stage have been conducted (Azeredo et al., 2015; Cabrera-Vique et al., 2015; Condon, Crepinsek, & Fox, 2009).

School feeding programmes are widespread. Countries with low and medium-income economies increasingly understand that Home Grown School Feeding (HGSF) initiatives, that connect the family local food farmers to governmental school feeding programmes, are fundamental opportunities to improve livelihoods for smallholder farmers and local communities and to strengthen the relationship between nutrition, agriculture and social protection (FAO, 2019; HGSF, 2019).

In Brazil, the Programa Nacional de Alimentação Escolar – PNAE (National School Feeding Programme) transfers resources for purchasing food from family farmers to be destined for school meals. According to Law 11947, at least 30% of the resources should be destined to purchase food from local family farming (Brasil, 2009). Brazil has 5570 municipalities (IBGE, 2017). The PNAE attended in 2016, 5333 municipalities and more than 40 million students were benefited by the PNAE resources (FNDE, 2018).

Mogi das Cruzes is one of the main cities of the green belt of São Paulo, with great importance in the food production (Santos & Bello, 2014). The municipality of Mogi das Cruzes buys food from 58 family farmers by using PNAE financial resources to feed students of 209 public schools. Family farmers transport the food to the Associação dos Produtores Rurais de Jundiapeba e Região (APROJUR) headquarters. APROJUR is a family farmers association that is in a rural area, near the most of 58 family farmers properties. In this shed, cooperatives perform cross-docking operation, separating the loads into 8 routes.

Family farmers complain about the high cost of distribution. The logistics operator argues that because of the high perishability, it is not possible to reduce the number of 8 routes because longer delivery times would deteriorate the food transported in small urban trucks. The staff of the municipality suggests the adoption of a new cross-docking point in the Departamento de Alimentação Escolar (DAE - School Feeding Department), a sector in charge of purchases, reception, storage and distribution of non-perishable foods. The DAE is in an urban area near many schools.

Governments try to ensure that all regions of the country have coverage of school feeding. This increases the political attractiveness of the programme, but dilutes the efficiency. There also may be a tendency to prefer covering urban areas to the detriment of rural areas, or schools that already have the infrastructure or are easier to reach than schools which would need additional investment in infrastructure or logistics (WFP, 2013).

In this context, questions can be raised: Is it possible to reduce the number of routes? The clustering of schools can be improved, aiming to reduce travel distances? The routing scenario can be analyzed and improved to reduce the distribution cost without a relevant influence on the distribution times?

This paper evaluates the scenario of the routing of the PNAE in the city of Mogi das Cruzes through spatial analysis in a Geographic Information system (GIS) and proposes an alternative routing scenario through the discrete events simulation, seeking to reduce the cost of the distribution of food purchased from family farming and without affecting transport times. This research adopted the QGIS and Arena tools for the spatial analysis and the simulation experiment respectively.

The results show a new routing scenario where the number of routes declined from 8 to 6 and the travel times were not steadily disturbed. The simulation considered the DAE facilities as a new cross-docking and distribution point.

The paper is organized as follows: In Section 2, a literature review brings information about School Feeding Programmes, the Mogi das Cruzes city and aspects about of the PNAE and Food Supply Chains. The methods are described in Section 3. Section 4 develops the spatial analysis using QGIS and the simulation experiment using Arena and results and discussions are provided. Finally, conclusions are given in Section 5.

2. Literature review

School feeding programmes are universal. The World Food Programme estimated that in 2013, 368 million children, or one in five, received a school meal at a total cost of US$ 75 billion. The rationales for school feeding investment are abating hunger, improving health and nutrition and improving schooling outcomes (Chakraborty & Jayaraman, 2019). School feeding programmes that operate in a planned number of days per year, with predetermined meals, and provide opportunities for local agriculture, generating stable and predictable demand, are the conceptual basis of the Home Grown School Feeding Programmes (Bundy, 2011; HGSF, 2014).

Studies have been conducted addressing food supply chains that connect local producers directly with consumers (Aubry & Kebir, 2013; Chiffoleau & Prevost, 2012; Mundler & Criner, 2016). About 90% of the 570 million of the rural properties in the world are small, and most are in developing countries and are operated by families. Many of these small family farmers have limited access to markets and services (FAO, 2019). The term utilized by the literature to define chains in which food is produced near the consumers, establishing a direct relationship of commercialization is Short food Supply Chains (Skallerud & Wien, 2019) and it was cited for the first time by (Marsden, Banks, & Bristow, 2000).

In Brazil, family farming is extremely important for agricultural production (Berchin et al., 2019). In 2006 there were 5,175,489 agricultural properties in Brazil. Within these properties, 4,367,902 were linked to family farming, representing almost 85% of the total (Froehlich et al., 2018).

Mogi das Cruzes has great relevance in the vegetables, fruits and flowers production in Brazil, besides the important portion of the national market of mushrooms, khaki, medlar, with great presence of farmers with a Japanese origin (Santos & Bello, 2014). Agricultural activity is remarkable. The number of agricultural establishments in the city was 1379 in 2017 (IBGE, 2019).

Detailed data on agricultural production in the municipality of Mogi das Cruzes are shown in table 1, in which the areas are divided by different characteristics (SÃO PAULO (Estado), 2008).

Table 1 – Agricultural data of Mogi das Cruzes ((SÃO PAULO (Estado), 2008)

	Quantity of properties	hectares
Total area	1,616	26,077.20
Perennial farming	574	1,905.30
Temporary farming	933	3,939.80
Pastures	190	2,109.20
Reforestation	358	5,773.80
Natural vegetation	954	7,058.70
Swamp and floodplain vegetation	272	495
Resting	678	2,367.50
Complementary	1,551	2,427.90

Delivery availability for loading and unloading operations is critical to reduce times and costs of logistics operations, as well as for improving city sustainability and livability. Planning with transportation

modelling through simulation allows computation of performance indicators to be used for assessment in studying delivery scenarios (Comi, Schiraldi, & Buttarazzi, 2018).

Despite the importance of the food industry, the management of food supply chains receives less attention from the literature. The reason can be the complex management of these chains and the specificity of the products and processes (Rong, Akkerman, & Grunow, 2011).

Many small farmers live in remote areas with poor road infrastructure, creating high transaction costs to access markets in the School feeding. In addition, the lack of a diversity of products and inadequate practices Post-harvest handling and storage generate difficulties for farmers compliance with the quality requirements of school feeding programmes (Maijers & Nalla, 2014).

Family farmers need logistical capabilities. It is common that the storage capacity and unitization of loads to be deficient and that knowledge about business models is low (Casey & Commandeur, 2016; Gelli, Kretschmer, Molinas, & de la Mothe, 2012).

The poor qualification of farmers, a small level of integration between producers, municipalities, logistics services providers and schools, and lack of knowledge of legal aspects of the school feeding program are noted in SFSCs (Lopes & Diniz, 2018). These issues combined with problems as the poor quality of roads, and inadequate vehicles can turn the logistics operation a crucial matter.

Organizations and cooperatives could provide the structure for family farmers to be competitive to provide for school feeding programmes (Maijers & Nalla, 2014), however, they face governance challenges, particularly in developing countries because of limited managerial skills and lack of financial resources (Royer, Bijman, & Abebe, 2017).

QGIS is an open source platform that is widely adopted in different analysis, as software modelling (Meyer & Riechert, 2019).

In distribution systems, there are many uncertainties involved in the operation, such as vehicles and products availability, loading time, unloading time, transport time, and demanded quantities. By generating random observations of the relevant probability distributions, the simulation can readily deal with these types of uncertainties and is used frequently to test various possibilities for project improvement and operation of these systems. A consecrated application of this type was the combination of mixed binary linear programming and simulation that reduced the annual costs with freight on more than US $7 million from Reynolds Metal Company (Hillier & Lieberman, 2013).

Among different simulation softwares, Arena has been applied by several researchers in various disciplines (Kamrani, Hashemi Esmaeil Abadi, & Rahimpour Golroudbary, 2014). Arena has been widely used to simulate traffic modes (Almaz & Altiok, 2012; Comi et al., 2018; Sancar Edis & Ornek, 2009) in different modes of transportation and various general or specialized simulation packages have been employed (Kamrani et al., 2014).

The benefits of modeling for decision making are the lower cost in relation to the interference in the real system, the anticipation of needed information, the usefulness of the models when it is impossible to perform tests in reality and the gains of insights and understanding about the investigated problem or object (Ragsdale, 2014).

3. Method

The methods adopted in this research are based on spatial analysis and discrete event simulation. We performed spatial analyses in a Geographic Information System (GIS). The PNAE's family farmers suppliers and the 209 schools of the network were geo-referenced. The spatial analysis allowed to study the current routes and to elaborate a new proposal for the routing. It also included the headquarters of APROJUR and DAE in the maps. The headquarters of APROJUR is the current distribution point and the headquarters of the DAE is a distribution alternative proposed by the staff of the Secretariat of Agriculture of the city of Mogi das Cruzes. The QGIS software was used.

The schools, producers, and headquarters of APROJUR and DAE were included in QGIS by using Keyhole Markup Language files, generated in Google Earth Pro software.

A discrete event simulation model was elaborated in the ARENA © software to compare the current distribution operation with a proposed alternative scenario. Simulation approach reduces the deficiencies in the existing pragmatic models.

The elimination of uncertainties related to cost, time and overall project management are possible by simulation models. Arena is an event management software extensively used for project managing purposes. The software includes diverse actions in terms of different modules that can be linked and sequenced (Frough, Khetwal, & Rostami, 2019).

The discrete events simulation was adopted instead of optimization methods because time of distribution is the most critical variable in the studied system, according to family farmers, schools and the logistics operator. The longest routes show a variation in the transport time because of the unpredictability of the traffic volume and roads paving conditions.

Besides the probabilistic behavior of the transport times, there are other reasons that justify the adoption of the discrete event simulation method. The model was elaborated to allow flexibility of studying of different routing scenarios. The animation resources are an important issue because it allows a deeper understanding of the proposed and tested scenarios.

The lack of actual data for the simulation modeling process occurs when the simulated systems do not exist, when the cost involved for the data collection is high or technically unfeasible, or when the involved actors do not provide the data by unavailability or confidentiality. The rule in these cases is to adopt intuitive distributions as exponential, to represent the time between successive arrivals, and triangular distribution when an estimation of typical, minimum and maximum values that can occur in the simulated system is known (Chwif, Medina, & Simulate, 2014).

Delays due to transportation and unloading in schools were collected and modeled. The eight different drivers provided varying times based on empirical skills in the transport operation. The minimum, typical and maximum times of the longest routes were requested. In the simulation model, the route times were represented by triangular distributions. Based on the empirical experience of the eight drivers, we also collected the unloading times in schools.

In order to increase the reliability of the simulation results, it is common to apply a big number of replications of the experiment until the confidence interval decreases, even though this practice can make

the study more time-consuming (Hillier & Lieberman, 2013). The number of replications can be defined by the formula (Kelton, 2014):

$$n = n_0 \frac{h_0^2}{h^2}$$

Where n_0 is the number of initial replications, and h_0 is the half width the model got from the n_0. The pre-specified desided for the half width of a choosen metric of the model is h.

Among the various techniques for validation of a simulation model, the face-to-face validation is one in which the analyst who assembled the model makes the conceptual validation and the validation of the results of the model, through the opinion of professionals with extensive experience and empirical knowledge of the simulated system. Other validation techniques are the duplication of models, in which two independent teams develop similar models, comparison with similar models previously developed, and sensitivity analysis, in which the influence of changes in input parameters in the results are pre-determined and tested (Chwif et al., 2014).

4. Results and discussion

The deliveries of the purchased food from family farmers are carried out by eight urban cargo vehicles. The headquarters of APROJUR is the current cross-docking point. The municipality's team suggested deploying a new cross-docking point in the DAE facilities, where the purchases of all food for school feeding are made and non-perishable foods are stocked. The DAE is in an urban area and cross-docking operations and deliveries to non-perishable food schools are carried out at this location.

Spatial analysis was built aiming the improvement of the clustering of schools. The different colors represent the eight delivery routes (figure 1) where the points are the 209 schools in Mogi das Cruzes city area. The cross-docking operation is performed at the APROJUR headquarters. A new scenario with 6 routes, where the headquarters of the DAE is a cross-docking point, was elaborated in the QGIS software. Figure 1 shows on the left side, the current routes and the right side, the proposed routes. The APROJUR's shed is represented by the green symbol and the DAE's headquarter is represented by the orange symbol.

The spatial analysis showed that the current routes do not adequately group the schools. The proposed routing scenario allowed to reduce the traveled distances by the small trucks. Because of the variability of route times, a simulation model was elaborated to compare the current scenario with the proposed scenario in the spatial analyses. Due to the high perishability, the aim of the simulation was to reduce the distribution efforts and to analyze the transport times, seeking for improvements. The family farmers harvest the food few hours before delivering. Shorter transport times can provide a very healthy and fresh diet for the students.

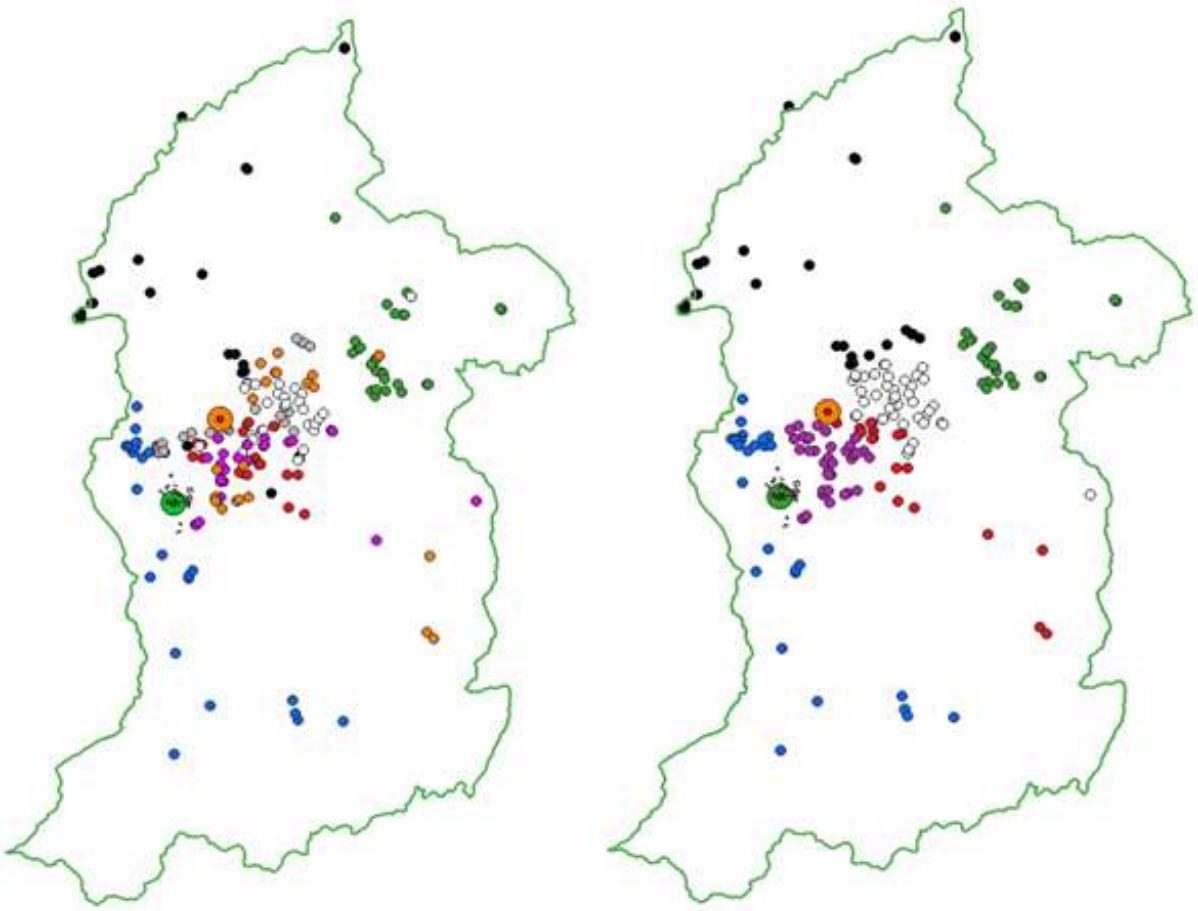


Figure 1 - Current and proposed routing scenarios by using QGIS (authors)

The schools were numbered from 1 to 209. The spatial analysis redefined the routing to decrease the total distance traveled. Table 1 shows the current routing and Table 2 shows the proposed routing, including the color of the points in each route.

Table 1 shows the sequence of visited schools on the left side of Figure 1. In table 2, the routes were reduced from 8 to 6 and routes 2, 3, 4, 5 and 6 are started on DAE as a cross-docking point and distribution, as a substitute of the APROJUR headquarters.

Both routing scenarios were studied by using simulation in the Arena software. The simulation seek for improvements in the transport time so that children's feeding is as healthy as possible. We also considered in the simulation model the change of the cross-docking point and distribution of the headquarters of APROJUR to the headquarters of the DAE suggested by the team of the city of Mogi das Cruzes.

We built the simulation model to allow the study of new routing scenarios without new logical modules, because of the use of expressions that index the sequences of schools visited and the transport times of each route in the Short Food Supply Chain.

Table 2 - current routing (authors)

	route 1 (green)	route 2 (blue)	route 3 (red)	route 4 (black)	route 5 (white)	route 6 (purple)	route 7 (orange)	route 8 (gray)
Cross-docking	APROJUR	APROJUR	APROJUR	APROJUR	APROJUR	APROJUR	APROJUR	APROJUR
	1	31	59	87	112	138	162	184
	2	32	60	88	113	139	163	185
	3	33	61	89	114	140	164	186
	4	34	62	90	115	141	165	187
	5	35	63	91	116	142	166	188
	6	36	64	92	117	143	167	189
	7	37	65	93	118	144	168	190
	8	38	66	94	119	145	169	191
	9	39	67	95	120	146	170	192
	10	40	68	96	121	147	171	193
	11	41	69	97	122	148	172	194
	12	42	70	98	123	149	173	195
	13	43	71	99	124	150	174	196
	14	44	72	100	125	151	175	197
Sequence of schools	15	45	73	101	126	152	176	198
	16	46	74	102	127	153	177	199
	17	47	75	103	128	154	178	200
	18	48	76	104	129	155	179	201
	19	49	77	105	130	156	180	202
	20	50	78	106	131	157	181	203
	21	51	79	107	132	158	182	204
	22	52	80	108	133	159	183	205
	23	53	81	109	134	160		206
	24	54	82	110	135	161		207
	25	55	83	111	136			208
	26	56	84		137			209
	27	57	85					
	28	58	86					
	29							
	30							

Table 3- proposed routing (authors)

	route 1 (green)	route 2 (blue)	route 3 (red)	route 4 (black)	route 5 (white)	route 6 (purple)
Cross-docking	APROJUR	DAE	DAE	DAE	DAE	DAE
Sequence of schools	1	186	59	110	113	77
	2	189	61	105	114	74
	3	188	67	106	115	75
	4	187	68	95	117	76
	5	185	69	163	118	122
	6	184	70	207	119	142
	7	31	72	205	120	143
	8	32	73	206	123	144
	10	33	78	204	126	147
	11	35	79	96	127	116
	12	36	80	100	128	196
	13	37	81	101	129	195
	14	38	82	102	130	194
	15	39	84	107	131	62
	16	40	94	108	133	63
	17	41	132	87	134	64
	18	42	125	88	135	65
	19	43	124	89	136	66
	20	44	155	97	137	60
	21	45	154	98	109	121
	22	46	157	99	111	148
	23	47	156	92	86	192
	24	48	153	93	85	149
	25	49	201	103	112	150
	26	50	190	104	166	151
	27	51	191	90	165	152
	28	52	198	91	164	170
	29	53	161	208	162	9
	30	54	183	209	168	34
	173	55	182		167	145
		56	181		169	146
		57	180		199	174
		58			200	141
					202	172
					201	171
					203	179
					71	177
					197	175
					83	178
					158	176
					159	138
					160	139
						140

The layout of the model has been shown in figure 2. The model assumes that the weight capacity of the vehicles is enough to transport the quantities of food historically demanded in the current and the proposed scenarios and that there is no change in the sequence of the visited schools, nor interruption in transport because of accidents or maintenance of the vehicles.

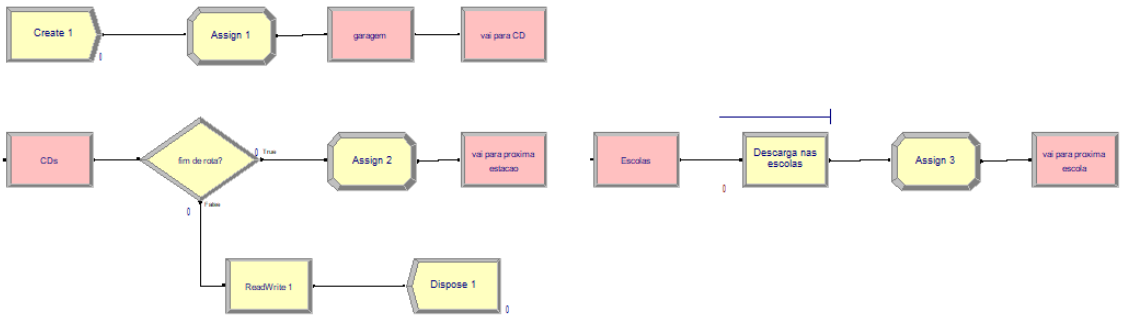


Figure 2 - Simulation model built in Arena software (authors)

The model elements are mainly logical and data modules. The model includes the Create, Process, Assign, Station, Route, Decide, Readwrite and Dispose logical modules and Resource, Set, Variable, Attribute and Expression data modules.

Create module has been parameterized to create 8 entities per arrival with a maximum number of 1 arrival in the current routing scenario. In the proposed scenario, the create module created 6 entities per arrival. The vehicles used in the deliveries are the entities of the model.

The Process module represents the unloading activity in schools. A total of 209 Resource modules represents each schools' team in the Process module. We interviewed the 8 drivers. They admit the times spent in unloading in different schools are similar. According to the driver's experience, the model assumes the expression TRIA (3,10,15) minutes for all 209 Resources modules for unloading activity.

The Station modules represent the cross-docking facilities and the schools. In both CDs and Schools Station modules, a station set members included APROJUR and DAE headquarters, and the 209 schools respectively. An expression based on the routing sequences of tables 1 and 2 indexed the destination parameter in the Route modules. The transport times were collected through drivers´ interviews. Transport times were validated in services of research and visualization of maps for comparison with the drivers' transport times.

We assume constant transport times for the very short routes. For the long routes time it was assigned triangular type distributions. The expressions syntax is TRIA (minimum route time, most likely route time and maximum route time). Tables 3 and 4 show the transport times of the current and proposed routing scenarios in the simulation model.

Table 4 – Sequence of transport times of current routing scenario (authors)

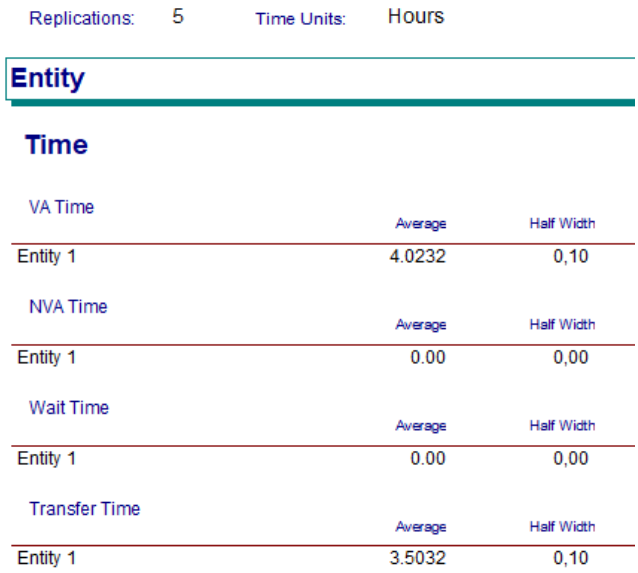
route 1	route 2	route 3	route 4	route 5	route 6	route 7	route 8
0	0	0	0	0	0	0	0
TRIA(35,45,70)	1	TRIA(20,23,50)	TRIA(40,44,70)	TRIA(20,24,50)	9	TRIA(20,22,50)	TRIA(10,11,25)
2	8	4	1	3	0	10	1
1	2	2	6	1	2	2	1
9	2	6	TRIA(35,42,60)	10	4	1	1
3	2	6	1	8	4	4	2
5	3	2	TRIA(35,42,60)	5	1	9	1
3	8	3	2	5	2	4	9
3	1	1	TRIA(30,35,60)	10	4	3	1
5	1	4	TRIA(20,25,50)	5	1	TRIA(15,20,40)	4
5	1	6	14	TRIA(12,16,30)	1	7	2
7	1	1	17	7	4	1	6
4	1	4	0	TRIA(12,16,30)	5	3	1
4	1	3	1	10	2	9	2
6	9	TRIA(12,13,25)	TRIA(20,23,40)	1	1	8	10
3	10	9	TRIA(12,13,25)	13	3	8	8
7	TRIA(12,13,25)	TRIA(20,23,40)	TRIA(12,13,25)	6	3	4	TRIA(10,13,25)
3	7	4	TRIA(20,26,50)	4	5	2	3
2	5	2	2	3	1	8	3
3	1	3	3	1	6	TRIA(15,20,40)	4
TRIA(12,15,25)	1	TRIA(10,11,25)	1	8	2	7	2
0	7	7	13	10	TRIA(10,11,25)	TRIA(20,24,45)	TRIA(10,12,25)
TRIA(25,30,60)	5	0	7	10	2	TRIA(20,27,45)	1
1	9	0	TRIA(20,22,40)	7	TRIA(12,14,30)		3
TRIA(12,14,25)	TRIA(12,13,25)	2	3	9	TRIA(10,12,25)		3
TRIA(12,17,30)	TRIA(12,17,30)	1	7	8			
TRIA(12,13,25)	5	3		3			
6	2	3					
1	10	0					
1							
TRIA(18,20,30)							

Table 5 – Sequence of transport times of proposed routing scenario (authors)

route 1	route 2	route 3	route 4	route 5	route 6
0	0	0	0	0	0
TRIA(35, 45, 60)	TRIA(8,11,20)	11	3	5	8
2	2	2	TRIA(10,11,15)	1	4
1	1	4	2	10	4
9	2	6	6	5	2
3	3	1	6	5	2
5	1	4	4	10	3
3	TRIA(8,11,20)	TRIA(10,13,20)	2	5	1
3	8	9	3	TRIA(10,16,25)	2
5	2	11	3	TRIA(10,13,20)	6
7	2	7	TRIA(10,16,25)	6	6
4	3	0	TRIA(15,18,30)	4	TRIA(10,11,20)
4	8	0	TRIA(10,13,20)	3	3
6	1	2	TRIA(10,13,20)	1	3
3	1	4	TRIA(15,17,25)	8	TRIA(10,12,20)
7	1	10	7	10	10
3	1	TRIA(10,15,25)	TRIA(20,26,35)	7	10
2	1	4	1	9	3
3	1	1	6	8	1
15	9	3	TRIA(15,17,25)	3	3
0	10	1	0	TRIA(10,17,25)	5
TRIA(20, 30, 35)	TRIA(10,13,20)	9	1	8	10
1	7	1	5	10	7
14	5	10	1	0	4
17	1	9	TRIA(20, 27,35)	TRIA(10,11,20)	2
13	1	12	1	3	1
6	7	1	TRIA(30,38,50)	3	4
1	5	7	3	0	4
1	9	TRIA(18,21,30)		3	6
TRIA(15,20,30)	TRIA(10,13,20)	TRIA(15,18,25)		8	6
TRIA(20,23,30)	TRIA(15,17,30)	TRIA(25, 27,35)		3	6
	5	TRIA(25,29,35)		4	1
	2	5		8	2
	10			3	7
				2	1
				4	2
				8	3
				TRIA(10,13,25)	3
				10	5
				8	1
				TRIA(12,16,25)	7
				1	5
				TRIA(10,13,20)	0

Assign modules allocated routes and the specific schools in each routes' sequence. The Station and Route modules were used to define the paths between the schools and the travelling times of each route. The station set members included the 209 schools in the Station module. The Readwrite module was used to collect the total transport times of each route in the different replications. The Dispose module ended the routes.

The eight drivers and the managers of the logistics operator validated the model which tested and concluded that the output results are similar compared to the actual operation. To observe the stochastic behavior of the simulation model, the results of five replications were performed, incorporating the uncertainties of the routing times. The half width results of the unloading and transfer times were 0.1 for an average of 4.02 and 3.5 hours respectively in the current routing scenario.



Replications: 5 Time Units: Hours

Entity

Time

VA Time

	Average	Half Width
Entity 1	4.0232	0,10

NVA Time

	Average	Half Width
Entity 1	0.00	0,00

Wait Time

	Average	Half Width
Entity 1	0.00	0,00

Transfer Time

	Average	Half Width
Entity 1	3.5032	0,10

Figure 3 - Arena's entity report (author)

Table 5 shows the route lines of the 8 routes. The distances from each of the 8 routes were calculated manually, without the use of the Arena variables. Route number 4 spends much more time than other routes and the distance traveled is higher. Balancing distances and transport times it is essential to ensure the food freshness. The shortest routes such as 6 and 8 spend proportionately shorter times compared to longer routes.

Table 6 - Transport times and distances of the current routing scenario (authors)

Route	Cross-docking and distribution point	Average travel time (minutes)	Distance (km)
1	APROJUR	273,87	103,4
2	APROJUR	152,93	75,2
3	APROJUR	168,83	63,25
4	APROJUR	414,04	202,57
5	APROJUR	212,94	70,5

6	APROJUR	108,32	44
7	APROJUR	236,87	92,25
8	APROJUR	113,74	39,28

Table 7 shows the path and distances of the 6 routes in the new proposed routing scenario. Only Route 1 maintained the headquarters of APROJUR as a point of cross-docking and distribution. The other routes depart from the DAE. The staff of the municipality states it is possible to transport the quantities of Routes 2 to 6 from APROJUR to the DAE with a local government truck.

table 7 - Transport times and distances of the proposed routing scenario (authors)

Route	Cross-docking and distribution point	Average travel time (minutes)	Distance (km)
1	APROJUR	263,04	112
2	DAE	184,23	85,95
3	DAE	263,01	118,4
4	DAE	262,76	147,82
5	DAE	295,09	107,35
6	DAE	194,65	78,9

Even with the reduction of the number of routes from 8 to 6, the proposed scenario reduced the total distance traveled. The average transport times per route increased in 0.5 hours, but with a lower standard deviation. The difference between the longest and shortest path times has decreased. Transport times are a key factor in maintaining the logistical operation at satisfactory levels of performance.

	Current routing scenario	Proposed routing scenario
Quantity of routes	8	6
Average number of schools per route	25,8	34,5
Total distance (km)	690,45	650,42
Total spent time of distribution operation (h)	28,03	24,38
Average travel time (h/route)	3,5	4,06
Standard deviation of transport times (h/route)	1,68	0,73
Average of unload times in schools (h/route)	4,02	5,36
Average route time (h/route)	7,52	9,42
Faster route time (h)	5,16	7,9
Slower route time (h)	11,1	12,03

5. Conclusions

School feeding programmes are essential actions to promote healthy feeding and better education indicators. In Brazil, the law 11947 guarantees the purchase of local family farming for school meals. The Brazilian National School Feeding Programme – PNAE, is a benchmark in the world.

This study analyzed the food supply chain of the PNAE in the city of Mogi das Cruzes. As cited in the literature, the program suffers from problems and difficulties in logistics operation because of the low qualification of family farmers and school managers on this field.

The research proved to be useful because it proposed a new scenario of routing with a reduction in the number of routes from 8 to 6, still achieving to reduce the total distance traveled and without substantially affecting the transport times, which is a critical variable in the study because of the high perishable items transported, and the government investment in the purchase of food directly from family farming. Other Brazilian cities can gain insights to study analogous situations.

In Mogi das Cruzes, managers can revise the cost of the logistics operation that impacts severely on the viability of the PNAES's Short Food Supply Chain based on the results of the proposed routing scenario. The research raises the study of other routing scenarios based on the simulation model. The modelling allows to simulate scenarios with higher or smaller number of routes and other routes' sequences of visited schools.

Increasing the number of replications of the model did not reduce the half width results. But we consider the limitations of this research are the impossibility of collecting measurements of transport and unloading times, which could provide higher assertiveness of the results. It is also a limitation of the research the lack of studies of another routing scenario that maintains the 8 original routes and could reduce the transport times, although possibly without significant impacts in reducing the costs of distribution.

It is suggested for future applications, the study involving other supply chain activities, including in the simulation model the receipt of food, the use of resources in the cross-docking activity and the inbound logistics in schools. Current standards of demand can be studied to scale the movement and transport capacity of vehicles. Similarly, new studies can prospect the capacity of transport movement assuming new scenarios with increased demanded quantities or including new items. It is also possible to study scenarios including new family farmers because the city has over 1000 small rural enterprises and only 58 actively take part in the PNAE.

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5 Considerações finais da pesquisa

Temas como segurança alimentar, programas de alimentação escolar e apoio à agricultura familiar têm sido ampla e globalmente discutidos. Esses assuntos estão incluídos na Agenda 2030 das Nações Unidas (ONU, 2015a) e representam grande potencial de avanços sociais e de saúde pública.

Mesmo com vários programas de alimentação escolar consolidados como importantes fontes de recursos para a compra de alimentos da agricultura familiar no mundo, problemas e dificuldades na gestão dessas cadeias de suprimentos são verificadas. Esse fato se deve ao baixo nível de qualificação em logística, de pequenos agricultores e dos funcionários das escolas.

As cadeias de suprimento são complexas e dinâmicas por tratar de itens perecíveis e porque a operação logística pode trazer dificuldades de gestão mesmo para os quadros de pessoal qualificado dos governos locais. A revisão de literatura evidenciou a dificuldade da gestão dessas *Short Food Supply Chains* em todo o Brasil e nos outros países com situações análogas.

Como citado com frequência na literatura , é comum existir em outras cidades e em outros países oportunidades de melhoria potenciais na operação logística das cadeias de suprimentos da alimentação escolar. Em Mogi das Cruzes, as dificuldades percebidas pela pesquisa são similares às encontradas na literatura.

Avanços operacionais podem trazer ganhos de escala para o PNAE e despertar maior interesse de adesão em novos produtores. Esse fato é relevante à medida que Mogi das Cruzes é um importante centro de produção local de alimentos, e essa característica e vocação da cidade sugerem grande potencial de ampliação do programa.

Esse estudo teve como objetivo principal analisar a operação logística da cadeia de suprimentos da alimentação escolar na cidade de Mogi das Cruzes, considerando os produtores rurais locais e a rede de escolas públicas do município, no âmbito do Programa Nacional de Alimentação Escolar (PNAE). A pesquisa buscou identificar oportunidades de melhorias logísticas com base na visão contextualizada dos agricultores familiares, das cooperativas de produtores, das escolas, da secretaria da educação, da secretaria da agricultura e do operador logístico responsável pela distribuição. A cadeia de suprimentos foi estudada e o entendimento de seu funcionamento operacional foi aprofundado adequadamente às pretensões iniciais da pesquisa. Equipes do governo municipal de Mogi das Cruzes, agricultores familiares, membros de cooperativas, equipe do operador logístico e profissionais das escolas da rede pública municipal foram contatados pessoalmente e informações vitais foram coletadas.

Esta pesquisa foi iniciada por um amplo diagnóstico da atividade agrícola no município de Mogi das Cruzes. Foram levantadas questões sobre a atuação do go-

verno municipal em apoio à atividade de agricultura familiar em uma abordagem baseada em estudo de caso. Dentre as diversas ações do município, está o Programa de Alimentação Escolar (PNAE), que adquire alimentos frescos de agricultores ativos no programa e são direcionados para a alimentação escolar de toda a rede pública de escolas.

A pesquisa aplicou métodos de análises espaciais, *Social Network Analysis* (SNA), *Analytic Hierarchy Process* (AHP) e Simulação de Eventos Discretos, na busca de levantar e avaliar alternativas de melhorias da operação logística do PNAE na cidade de Mogi das Cruzes.

Um dos objetivos específicos foi mapear a cadeia de suprimentos agroalimentar *(Short Food Supply Chain)* envolvendo a operação logística do Programa Nacional de Alimentação Escolar na cidade de Mogi das Cruzes, para maior entendimento e maior aprofundamento nas análises. Para cumprir esse objetivo, vários estudos foram conduzidos em Sistema de Informações Geográficas (GIS). O georreferenciamento das escolas, dos produtores, da sede da APROJUR e do DAE foram incluidos nos vários mapas elaborados.

O método *hotspot map* permitiu que as áreas com maiores níveis de concentração de escolas fossem identificadas. Com base nessa análise, foi possível avaliar as distâncias em relação à sede da APROJUR, local de origem da distribuição dos alimentos frescos entregues pelos produtores. A sede da APROJUR está localizada na área rural de assentamento dos produtores ativos no PNAE. A má qualidade das estradas é um dos obstáculos à eficiência da operação logística. Muitas escolas estão afastadas desse local, principalmente àquelas localizadas na região central e na região ao norte do município.

Também foram analisadas as distâncias em relação ao Departamento de Alimentação Escolar (DAE), e foi sugerido como um novo ponto de distribuição. A maior concentração das escolas está em áreas urbanas e há escolas mais afastadas das regiões centrais do município, que representam um desafio em termos de tempos e custos logísticos.

As análises espaciais realizadas com base nos mapas e estudos visuais da rede composta por escolas e produtores permitiram perceber que escolas estão espalhadas pelo município de forma que a roteirização é complexa por apresentar múltiplas alternativas de sequenciamento, de número de escolas por rota, da capacidade de veículos utilizados, e das diferentes possibilidades de pontos de *cross-docking* e armazenamento. Há escolas em áreas pouco urbanizada e distantes das áreas centrais. Os produtores familiares estão localizados próximos em área de assentamento, em que há estradas sem pavimentação e estão distantes da maior parte das escolas atendidas.

Outro objetivo específico da pesquisa foi avaliar o fluxo de alimentos a partir

dos produtores locais até as escolas. O método *Social Network Analysis* (SNA) foi adotado para que a demanda e o fluxo dos alimentos adquiridos junto à agricultura familiar fossem analisados sob a perspectiva dos diagramas de redes sociais. Várias redes foram elaboradas. Foram identificadas relações entre cooperativas, alimentos e escolas. O método se mostrou bastante apropriado, levantando uma ampla gama de informações sobre quantidades e volumes que fluem a partir das cooperativas para as escolas.

O método também permitiu conhecer as relações binárias entre os diferentes tipos de alimentos adquiridos e as escolas, identificando grupos de escolas que consomem itens específicos de alimentos. Essas descobertas são típicas em análises de redes. Planilhas e tabelas perdem eficiência quando se pretende realizar esses tipos de análise, pois não permitem a identificação de relações ou a falta de relações entre múltiplos atores de uma rede por meio visual. Também foi possível conhecer e classificar os graus de importância e influência dos atores em termos da operação logística e das quantidades que fluem na rede.

Similarmente foi proposto o levantamento da visão integrada dos diversos atores da cadeia de suprimentos para avaliar fatores de maior impacto e alternativas de melhoria logística no PNAE. O método AHP foi adotado para que a análise dos fatores que mais impactam na logística da alimentação escolar fosse realizada de forma a considerar os julgamentos consolidados dos principais atores da cadeia de suprimentos.

Durante a pesquisa, opiniões e visões diversas foram manifestadas por produtores, escolas, governo local e especialistas. Iniciou-se a aplicação do método AHP pela elaboração da árvore de decisão e sua validação junto ao grupo de especialistas que contribuiu com a pesquisa. A partir da árvore validada, o questionário para coleta de julgamentos em pares com escala *likert* foi originado.

A coleta dos julgamentos ocorreu em eventos realizados pelo governo local. Produtores responderam o questionário sob a orientação do pesquisador durante palestra dos técnicos da secretaria da agricultura do município.

As escolas preencheram os questionários sob a orientação do pesquisador com apoio de equipe treinada previamente, composta por alunos do curso de agronegócio da Fatec Mogi das Cruzes, que atuaram como voluntários. Os especialistas colheram seus respectivos julgamentos em gabinete. As análises de critérios e alternativas de melhoria segundo sua pontuação foram realizadas por grupos de respondentes e de forma consolidada. O estudo permitiu agregar visão ampla dos principais atores da SFSC na busca de alternativas de melhoria na logística do sistema em uma análise multicritério.

O último objetivo específico proposto foi analisar e sugerir melhorias na operação de distribuição de alimentos na cadeia de suprimentos formada pelos produto-

res rurais locais, cooperativas e escolas públicas que se beneficiam dos recursos do PNAE. Os métodos GIS e SNA forneceram embasamento para a fase final da pesquisa, em que foi adotado o método de Simulação de Eventos Discretos. As análises espaciais contribuíram com a visão do sistema de distribuição e com mapas em que foram inseridas as rotas atuais de distribuição e as rotas propostas. O método AHP demonstrou que a mudança do ponto de *cross-docking* para as instalações do DAE é uma alternativa que devia ser considerada na simulação. Também demonstrou que melhorias logísticas devem ser implementadas.

O modelo de simulação foi construído para que as alternativas levantadas pelo SNA possam ser avaliadas com mudança de parâmetros, sem que seja necessário o esforço de construção de novos modelos. Pode-se, por exemplo avaliar propostas de cenários em que sejam incluídas padronizações de menus servidos em toda a rede ou ampliar a padronização dos menus para um número maior de escolas. Novos fluxos de alimentos com mudança na ocupação da capacidade dos veículos podem ser analisados sem novos esforços de modelagem.

Estudos de simulação são onerosos em termos de recursos de tempo dispendido por analistas especializados e nesse contexto, a utilização do modelo desenvolvido de forma flexível representa um avanço importante nas possibilidades de estudos que proporcionem maior entendimento do sistema logístico da alimentação escolar, não apenas em Mogi das Cruzes, mas em outros municípios com problemas análogos. Novos *insights* podem ser obtidos por meio do modelo desenvolvido alterando-se os parâmetros e utilizando os recursos de animação para envolver novos colaboradores como a equipe do Departamento de Alimentação Escolar (DAE) e outros assessores da Secretarias da Educação e Agricultura do município de Mogi das Cruzes.

A pesquisa adotou métodos consolidados cientificamente e de caráter bastante quantitativos. O uso conjugado desses métodos pode significar a criação de um modelo de gestão de *Short Food Supply Chains*. Esse modelo mostra potencial de ser aplicado em outras cidades do Brasil que se beneficiam do PNAE.

Vários assuntos podem ser abordados em estudos futuros a partir das temáticas discutidas pela pesquisa. Pode-se estabelecer um modelo de gestão de SFSCs destinadas à alimentação escolar e aplicar em cidades localizadas fora do Brasil, já que a literatura traz informações de que as dificuldades logísticas em programas *Home Grown School Feeding* são similares às encontradas nas cidades brasileiras.

O modelo pode ser replicado para cidades que não tenham a importância de Mogi das Cruzes como produtoras de alimentos. Essas cidades necessariamente precisam comprar alimentos de agricultores familiares localizados em outros municípios, fato que pode dificultar ainda mais a operação logística do PNAE.

É possível estudar outras atividades logísticas como embalagens, movimentação, sistemas de armazenagem, recebimento e separação (*picking*), gestão de de-

manda e de estoques. Atividades de intralogística podem ser analisadas nas escolas, nos pontos de distribuição e nos produtores familiares. O estudo da coordenação das SFSCs da alimentação escolar podem ser elaborados, buscando reduzir incertezas de demanda e oferta e diminuir a imprevisibilidade nas operações de produção, movimentação e distribuição.

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A Apêndice A - Visitas à secretaria da Agricultura de Mogi das Cruzes

Fotos das visitas à secretaria da Agricultura

Figura 23: Visita secretaria da agricultura - foto 1

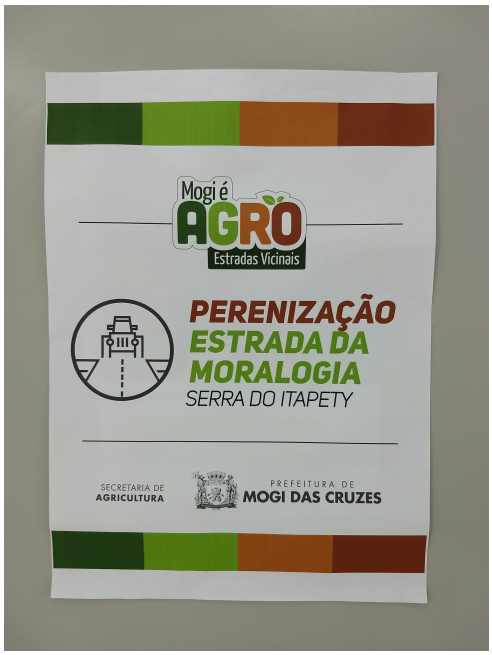


Figura 24: Visita secretaria da agricultura - foto 2

B Apêndice B - Questionário AHP

Questionário aplicado para levantamento dos julgamentos dos fatores que mais impactam na logística da merenda escolar em Mogi das Cruzes

MERENDA ESCOLAR - QUEM É MAIS IMPORTANTE? QUEM IMPACTA MAIS? ESCOLHA ENTRE DUAS OPÇÕES E DÊ A NOTA

*Obrigatório

1. **Logística na escola (manuseio, descarga, estoque) ou os produtores familiares?** *
   Marcar apenas uma oval.

   - ◯ Logística nas escolas
   - ◯ Produtores

2. **Nota (quanto mais importante?)** *
   Marcar apenas uma oval.

	0	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

3. **Logística na escola (manuseio, descarga, estoques) ou a distribuição (coleta e entrega) de alimentos?** *
   Marcar apenas uma oval.

   - ◯ logística nas escolas
   - ◯ distribuição

4. **Nota (quanto mais importante?)** *
   Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

5. **Logística na escola (manuseio, descarga, estoques) ou a prefeitura?** *
   Marcar apenas uma oval.

   - ◯ logística nas escolas
   - ◯ prefeitura

6. **Nota (quanto mais importante?)** *
   Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

7. **Logística na escola (manuseio, descarga, estoques) ou CAE?** *
Marcar apenas uma oval.

- ◯ Logística interna nas escolas
- ◯ CAE

8. **Grau de importância** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

9. **Produtores familiares ou a distribuição?** *
Marcar apenas uma oval.

- ◯ Produtores
- ◯ Distribuição (coleta e entrega)

10. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

11. **Produtores familiares ou a prefeitura?** *
Marcar apenas uma oval.

- ◯ Produtores
- ◯ prefeitura

12. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

13. **Produtores familiares ou o CAE?** *
Marcar apenas uma oval.

- ◯ Produtores
- ◯ CAE

14. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

15. **Distribuição ou a prefeitura?** *
Marcar apenas uma oval.

- ◯ Distribuição (coleta e entrega)
- ◯ prefeitura

16. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

17. **Distribuição ou o CAE?** *
Marcar apenas uma oval.

- ◯ Distribuição (coleta e entrega)
- ◯ CAE

18. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

19. **Prefeitura ou o CAE?** *
Marcar apenas uma oval.

- ◯ prefeitura
- ◯ CAE

20. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

21. **Nas escolas: manuseio ou os pedidos?** *
Marcar apenas uma oval.

- ◯ manuseio
- ◯ pedidos

22. **Nota** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

23. **Nas escolas: o manuseio ou o estoque?** *

Marcar apenas uma oval.

- manuseio
- estoque

24. **Nota (quanto mais importante?)** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz										muito mais importante

25. **Nas escolas: os pedidos ou o estoque?** *

Marcar apenas uma oval.

- pedidos
- estoque

26. **Nota (quanto mais importante?)** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz										muito mais importante

27. **Para produtores: a previsão da quantidade que vai ser comprada pela prefeitura ou a mão-de-obra de produção?** *

Marcar apenas uma oval.

- demanda
- mão-de-obra

28. **Nota (quanto mais importante?)** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz										muito mais importante

29. **Para produtores: a previsão da quantidade que vai ser comprada pela prefeitura ou o baixo interesse deles pela agricultura familiar na merenda?** *

Marcar apenas uma oval.

- previsão
- interesse

30. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

31. **Para produtores: a mão-de-obra ou o interesse deles pela agricultura familiar na merenda?** *
Marcar apenas uma oval.

- ◯ mão-de-obra
- ◯ baixo interesse

32. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

33. **Para a distribuição: armazenagem no galpão antes da entrega ou as rotas escolhidas?** *
Marcar apenas uma oval.

- ◯ armazenagem
- ◯ rotas

34. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

35. **Para a distribuição: a armazenagem ou o manuseio no galpão?** *
Marcar apenas uma oval.

- ◯ armazenagem
- ◯ manuseio

36. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

37. **Para a distribuição: rotas escolhidas (do galpão até as escolas) ou o manuseio?** *
Marcar apenas uma oval.

- ◯ rotas
- ◯ manuseio

38. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

39. **Para a prefeitura: secretaria da agricultura ou a secretaria da educação?** *
Marcar apenas uma oval.

- ◯ sec agricultura
- ◯ sec educação

40. **Nota (quanto mais importante)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

41. **Para o CAE: a legislação ou a gestão das escolas?** *
Marcar apenas uma oval.

- ◯ legislação
- ◯ gestão nas escolas

42. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

43. **Para o manuseio nas escolas: distribuir pelo DAE ou treinar o pessoal (mão-de-obra)?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

44. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

45. **Para o manuseio nas escolas: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

46. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

47. **Para o manuseio nas escolas: treinar a mão-de-obra ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

48. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

49. **Para melhorar os pedidos das escolas: distribui pelo DAE ou treina o pessoal (a mão-de-obra)?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

50. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

51. **Para melhorar os pedidos das escolas: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

52. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

53. **Para melhorar os pedidos das escolas: treinar o pessoal ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

54. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

55. **Para melhorar os estoques das escolas: distribui pelo DAE ou treina o pessoal (mão-de-obra)?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

56. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

57. **Para melhorar estoques das escolas: distribui pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

58. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

59. **Para melhorar estoques das escolas: treinar o pessoal ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

60. **Nota (quanto mais importante?)** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

61. **Para melhorar a previsão de produção de alimentos: distribuir pelo DAE ou treinar mão-de-obra?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

62. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

63. **Para melhorar a previsão de produção de alimentos: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

64. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
Tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

65. **Para melhorar a previsão de produção de alimentos: treinar mão-de-obra ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

66. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

67. **Para melhorar o trabalho dos produtores e da preparação da merenda: distribuir pelo DAE ou treinar o pessoal (mão-de-obra)?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

68. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

69. **Para melhorar o trabalho dos produtores e da preparação da merenda: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

70. **Grau de importância** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

71. **Para melhorar o trabalho dos produtores e da preparação da merenda: treinar o pessoal (mão-de-obra) ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ treina o pessoal das escolas

72. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
Tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

73. **Para aumentar interesse dos produtores de alimentos na merenda: distribuir pelo DAE ou treinar a mão-de-obra?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

74. **Grau de importância** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

75. **Para aumentar interesse dos produtores de alimentos na merenda: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

76. **Grau de importância** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

77. **Para aumentar interesse dos produtores de alimentos na merenda: capacitar a mão-de-obra ou melhorar a logística de distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

78. **Grau de importância** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

79. **Para melhorar armazenagem: distribuir pelo DAE ou treinar a mão-de-obra?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

80. **Grau de importância** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
igual importância	◯	◯	◯	◯	◯	◯	◯	◯	◯	absoluta importância

81. **Para melhorar a armazenagem: distribuir pelo DAE ou melhorar distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

82. **Quanto mais importante** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

83. **Para melhorar a armazenagem: treinar mão-de-obra ou melhorar a distribuição?** *

Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

84. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

85. **Para melhorar as rotas para entregas: distribuir pelo DAE ou treinar mão-de-obra?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

86. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

87. **Para melhorar as rotas de entregas: distribuir pelo DAE ou melhorar distribuição?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

88. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

89. **Para melhorar as rotas de entregas: treinar mão-de-obra ou melhorar a distribuição?** *

Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

90. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

91. **Para melhorar o manuseio nas escolas: distribuir pelo DAE ou treinar mão-de-obra?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

92. **Quanto mais importante** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

93. **Para melhorar o manuseio nas escolas: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ Outro: _____

94. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

95. **Para melhorar o manuseio nas escolas: treinar mão-de-obra ou melhorar distribuição?** *
Marcar apenas uma oval.

- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ treina o pessoal das escolas

96. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

97. **Para melhorar a atuação da secretaria da agricultura: distribuir pelo DAE ou treinar mão-de-obra?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

98. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

99. **Para melhorar a atuação da secretaria da agricultura: distribui pelo DAE ou melhorar distribuição?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ Outro: _____

100. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

101. **Para melhorar a atuação da secretaria da agricultura: treinar mão-de-obra ou melhorar a distribuição?** *

Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

102. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

103. **Para melhorar a atuação da secretaria da educação: distribuir pelo DAE ou treinar mão-de-obra?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

104. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

105. **Para melhorar a atuação da secretaria da educação: distribuir pelo DAE ou melhorar a distribuição?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ Outro: _____

106. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

107. **Para melhorar a atuação da secretaria da educação: treinar mão-de-obra ou melhorar a distribuição?** *

Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

108. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

109. **Para ajudar as escolas: distribuir pelo DAE ou treinar mão-de-obra?** *

Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

110. **Quanto mais importante?** *

Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

111. **Para ajudar as escolas: distribuir pelo DAE ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ Outro: _____

112. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

113. **Para ajudar as escolas: treinar a mão-de-obra ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

114. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

115. **Para ajudar a cumprir a legislação: distribui pelo DAE ou treinar mão-de-obra?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ treina o pessoal das escolas

116. **Quanto mais importante** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

117. **Para ajudar a cumprir a legislação: distribuir pelo DAE ou melhorar distribuição?** *
Marcar apenas uma oval.

- ◯ traz tudo da APROJUR e distribui pelo DAE
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)
- ◯ Outro: _____

118. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

119. **Para ajudar a cumprir a legislação: treinar mão-de-obra ou melhorar a distribuição?** *
Marcar apenas uma oval.

- ◯ treina o pessoal das escolas
- ◯ melhorar a distribuição (estudar rotas, melhorar embalagens, melhorar carga e descarga)

120. **Quanto mais importante?** *
Marcar apenas uma oval.

	1	2	3	4	5	6	7	8	9	
tanto faz	◯	◯	◯	◯	◯	◯	◯	◯	◯	muito mais importante

C Apêndice C - Aplicação dos questionários para agricultores e escolas

Figura 25: Coleta de julgamentos na APROJUR - foto 1

Figura 26: Coleta de julgamentos na APROJUR - foto 2

Figura 27: Coleta de julgamentos na APROJUR - foto 3

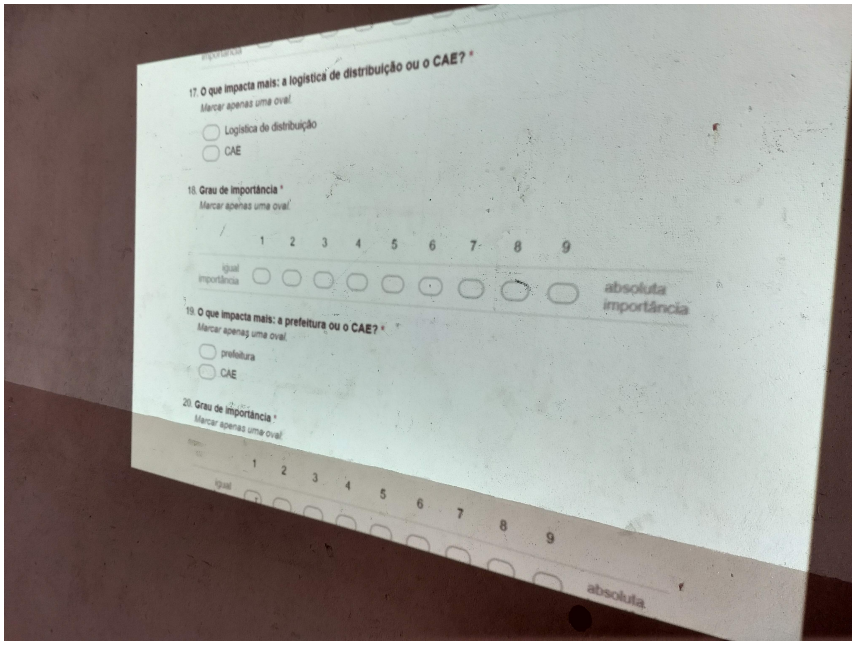


Figura 28: Coleta de julgamentos na APROJUR - foto 4

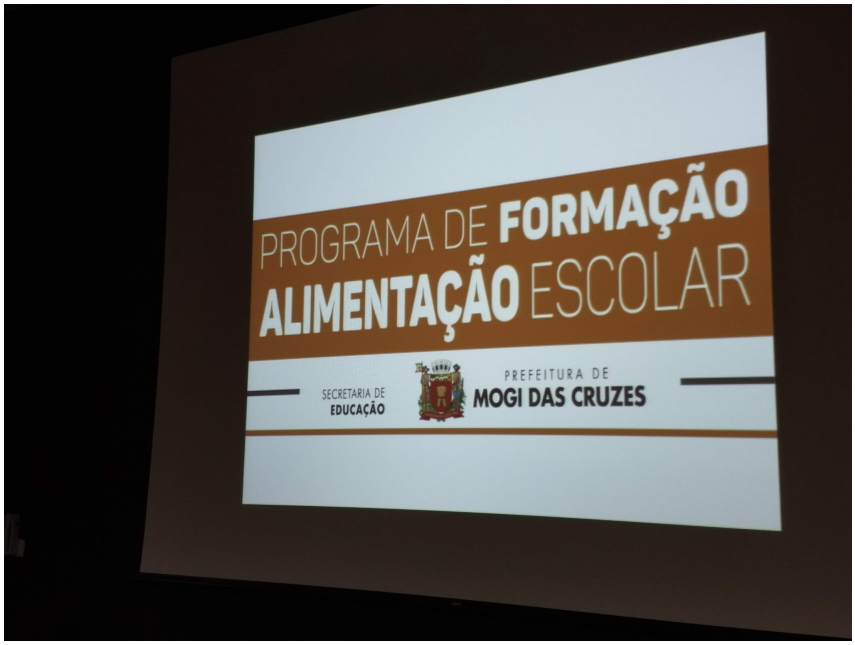


Figura 29: Coleta de julgamentos das escolas - foto 1

Figura 30: Coleta de julgamentos das escolas - foto 2

Figura 31: Coleta de julgamentos das escolas - foto 3

D Apêndice D - Participação em eventos

Para apoiar o embasamento conceitual da pesquisa, houve a participação em eventos científicos. O foco foi participar de discussões e entrar em contato com publicações análogas às temáticas desenvolvidas como agricultura familiar, produção local de alimentos, cadeias de suprimentos de alimentos, alimentação escolar e métodos quantitativos decisórios aplicados em operações logísticas. Foram apresentados trabalhos nos eventos:

- *Advances in Production Management Systems* (APMS) realizado na cidade de Foz do Iguaçú no ano de 2016
- IFLOG realizado na cidade de Suzano no ano de 2017
- FATECLOG realizado na cidade de Santos no ano de 2018, onde ocorreu lançamento do livro Engenharia de Produção aplicada ao Agronegócio, em que consta capítulo de autoria conjunta do orientador e do autor da presente tese, intitulado Pesquisa Operacional Aplicada ao Agronegócio
- *Global Food Security* realizado na cidade de *Cape Town* na África do Sul no ano 2017
- NETLOG realizado na cidade de São Paulo no ano de 2018

E Anexo I - Resposta da Secretaria da Educação da solicitação de informações para estudo de fluxos

Memorando nº 10 / 2018 - SME

Mogi das Cruzes, 22 de fevereiro de 2018.

Eliana Mangini
Diretora
Departamento Alimentação Escolar

Assunto: Informações Pesquisa - PNAE.

Anexo a este Memorando encaminho solicitação de levantamento de dados do aluno João Roberto Maiellaro, doutorando no Programa de Pós Graduação em Engenharia de Produção da Universidade Paulista, referente ao Programa Nacional de Alimentação Escolar – PNAE.

Solicito providências e retorno a este Gabinete quanto às informações solicitadas pelo aluno.

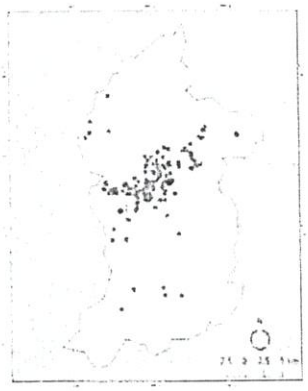
Atenciosamente,

Juliana de Paula Guedes de Melo Santos
Secretária de Educação

A Exma. Secretaria da Educação de Mogi das Cruzes
Sra. JULIANA GUEDES

A Exma. Diretora do Departamento de Alimentação Escolar
Sra. ELIANA MANGINI

Meu nome é João Roberto Maiellaro, professor titular das fatecs Zona Leste, Guarulhos e Sebrae, e doutorando no programa de pós-graduação em engenharia de produção da Universidade Paulista – UNIP (nota 5 CAPES).
Em parceira com a Fatec Mogi das Cruzes e Secretaria da Agricultura de Mogi das Cruzes, estamos desenvolvendo pesquisa sobre a logística da cadeia de suprimentos que envolvem o PNAE, em que atuam à jusante, produtores locais de alimentos, e à montante, escolas atendidas.
O objetivo é aplicar técnicas de gerenciamento de redes de transporte e técnicas baseadas em pesquisa operacional (como programação matemática linear, *analytic hierarchy process* e simulação de eventos discretos) para encontrar melhorias logísticas e redução de custos logísticos. Nossa pesquisa tem grande potencial para auxiliar a gestão desse sistema.
Até o momento foram realizadas análises geoespaciais das escolas, dos produtores e do ponto de *cross-docking* (APROJUR), num ambiente de Sistema de Informação Geográfica (SIG). Uma das análises obtidas está na figura a seguir.



Pedimos a gentileza de ter acesso a alguns dados junto ao Departamento de Alimentação Escolar para continuidade da pesquisa, referentes ao PNAE:

a) Quantidades consumidas dos alimentos por escola em 2017
b) Quantidades adquiridas por alimento por produtor (ou por cooperativa) em 2017

Esses dados permitirão aprofundar e detalhar estudos da rede de transporte. Com o avanço da pesquisa, gostaríamos de solicitar novos dados conforme sejam demandados.

Reiteramos que os fins são exclusivamente científicos e acadêmicos.

Certos de que podemos estabelecer relação de confiança e de grande contribuição mútua por meio de pesquisa acadêmica, não apenas no âmbito dessa pesquisa, mas para futuras necessidades do governo local, subscrevemo-nos

FERNANDO JUABRE MUÇOUÇAH
Diretor da Fatec Mogi das Cruzes

ROBSON DOS SANTOS
Diretor da Fatec Zona Leste

JOÃO R MAIELLARO
Doutorando Eng Produção (UNIP)
Coordenador curso de logística Fatec ZL
Membro Comitê Coord. Logística do Centro Paula Souza

Renato Augusto Abdo
Secretário de Agricultura

SECRETARIA DE **EDUCAÇÃO**

PREFEITURA DE **MOGI DAS CRUZES**

PROCESSO Nº	EXERC.	FOLHA Nº
	2018	
02/03/18		
DATA		RUBRICA

INTERESSADO: **João Roberto Maiellaro – Professor da Fatec**

FOLHA DE INFORMAÇÃO OU DESPACHO

À Senhora Secretária Municipal de Educação:

Em reposta ao Memorando N.º 10/2018-SME, encaminhamos as informações solicitadas pelo professor das Fatecs Zona Leste, Guarulhos e Sebrae, o Sr. João Roberto Maiellaro.

Salientamos que os produtos e respectivas quantidades aqui apresentados correspondem ao consumo de produtos oriundos da Agricultura Familiar no ano de 2017, que foram pagos com a verba repassada pelo FNDE (Fundo Nacional de Desenvolvimento da Educação) em atendimento ao PNAE (Programa Nacional de Alimentação Escolar).

Consumo de Legumes e Verduras da Agricultura Familiar por Cooperativa

Consumo em Unidade de Produto			
COOPERATIVA	**PRODUTO**	**UNID**	**CONSUMO 2017**
COAIPRO	ACELGA	UNID	2.312
	ALFACE CRESPA	UNID	4.240
	REPOLHO LISO	UNID	2.501
COOPAVAT	ACELGA	UNID	11.241
	ALFACE CRESPA	UNID	20.010
	CEBOLINHA	MÇ	4.250
	COUVE-FLOR	UNID	3.473
	COUVE MANTEIGA	UNID	3.588
	ESCAROLA	UNID	15.352
	REPOLHO LISO	UNID	8.004
	SALSA	MÇ	4.250
	BETERRABA	PCT	1.000
	AGRIÃO	PCT	1.031
	CENOURA	PCT	2.001
	CHUCHU	PCT	1.564
	ABOBRINHA	PCT	4.002
COOPROJUR	ACELGA	UNID	13.117
	ALFACE CRESPA	UNID	25.748
	CEBOLINHA	MÇ	4.250
	COUVE MANTEIGA	UNID	3.612
	ESCAROLA	UNID	15.397
	REPOLHO LISO	UNID	10.495
	SALSA	MÇ	4.250
	CENOURA	PCT	5.000

SECRETARIA DE **EDUCAÇÃO**

PREFEITURA DE **MOGI DAS CRUZES**

PROCESSO Nº	EXERC.	FOLHA Nº
	2018	
02/03/18		
DATA		RUBRICA

INTERESSADO: **João Roberto Maiellaro – Professor da Fatec**

FOLHA DE INFORMAÇÃO OU DESPACHO

Consumo em KG			
COOPERATIVA	**PRODUTO**	**UNID**	**CONSUMO 2017**
COAIPRO	ACELGA	KG	3.699,2
	ALFACE CRESPA	KG	1.696,0
	REPOLHO LISO	KG	5.002,0
	COAIPRO Total (KG)		**10.397,2**
COOPAVAT	ACELGA	KG	17.985,6
	ALFACE CRESPA	KG	8.004,0
	CEBOLINHA	KG	850,0
	COUVE-FLOR	KG	3.473,0
	COUVE MANTEIGA	KG	1.794,0
	ESCAROLA	KG	6.140,8
	REPOLHO LISO	KG	16.008,0
	SALSA	KG	850,0
	BETERRABA	KG	2.000,0
	AGRIÃO	KG	1.546,5
	CENOURA	KG	4.002,0
	CHUCHU	KG	3.128,0
	ABOBRINHA	KG	8.004,0
	COOPAVAT Total (KG)		**73.785,9**
COOPROJUR	ACELGA	KG	20.987,2
	ALFACE CRESPA	KG	10.299,2
	CEBOLINHA	KG	850,0
	COUVE MANTEIGA	KG	1.806,0
	ESCAROLA	KG	6.158,8
	REPOLHO LISO	KG	20.990,0
	SALSA	KG	850,0
	CENOURA	KG	10.000,0
	COOPROJUR Total (KG)		**71.941,2**

CONSUMO TOTAL (KG)	**156.124,3**

SECRETARIA DE
EDUCAÇÃO

PREFEITURA DE
MOGI DAS CRUZES

PROCESSO Nº	EXERC.	FOLHA Nº
	2018	

02/03/18
DATA RUBRICA

INTERESSADO: **João Roberto Maiellaro – Professor da Fatec**

FOLHA DE INFORMAÇÃO OU DESPACHO

Informamos que as tabelas apresentadas anteriormente atendem ao item b), mas que a planilha para atendimento da solicitação do item a), das quantidades consumidas dos alimentos por unidade escolar, segue em anexo a este documento.

Após análise superior, encaminhar para o Sr. João Roberto Maiellaro.

DAE, em 02 de março de 2018.

Eliana Aparecida Prado Mangini
Diretora do Departamento de Alimentação Escolar