| | MILESTONE PROGRESS IN THE ENTIRE PROJECT TERM (DECEMBER 2014- MARCH 2018) | | |
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| **No** | Milestone Description | Progress and Evidence | Comments |
| **1** | Inception workshop with key partners and stakeholders held (New Delhi/Coimbatore) and report shared (Guelph/TNAU). | Completed<br><br>Refer MN 06 joint technical report | Successfully completed in January 2015 @ Bangalore |
| **2** | Recruitment of project staff, including research fellows and associates (12) and enrolment of post-graduate students (three each for Masters, MPhil and PhD) completed and essential equipment purchased (UG, SUA, UWI, UoN and ITI). | Completed<br><br>Refer MN 06 and MN 18 joint technical report | Though some delays in purchasing equipment's but completed on or before MN18 reporting period |
| **3** | Development of key project strategies including: (i) M&E framework, (ii) communications strategy, (iii) gender strategy and (iv) scaling-up approach completed (UG /All partners) | Completed<br><br>Refer MN 06 and MN 18 joint technical report | Strong internal and external communication strategy was developed and followed throughout the project term. Scaling up approach by large scale trials and resulted in a Canadian company investment. Gender strategy reflected in Socio economic models |
| **4** | Bio-safety report on hexanal completed and policy brief developed (UG /TNAU) | Completed<br><br>Refer MN 06 technical report | See the outcome stories (Green Nanotechnology and Biosafety of nano-products) and publications |
| **5** | Research protocols for baseline surveys approved by respective ethics boards (All) | Completed<br><br>Refer MN 06 technical report | UG, UoN and TNAU got their REB clearance in 2015. ITI, Sri Lanka, SUA, Tanzania and UWI, Trinidad and Tobago don't need a REB clearance, and hence it is proposed that they are covered under UG REB clearance. |
| **6** | Identification of farmers, fields or industry outlets (for postharvest studies) for trials completed. Begin on-farm activities where applicable (UWI, UoN, SUA, ITI) | Completed<br><br>Refer MN 06 technical report | |
| **7** | Extend MoU on intellectual property rights for UG, TNAU, and ITI and create related MoU for the new partners (UG). | Completed<br><br>Refer MN 06 technical report | |
| **8** | Initiation of licensing activities and Identification of suitable partner[s]/mechanism for commercialization of Enhanced Freshness Formulation (EFF) sprays in India (UG / TNAU | Completed<br><br>Refer MN 18,24,30 and 36 technical report | Initial licensing agreement signed with Harvest one Agritech (Canadian Company) and it got switched Novus Merchants who licensed this product under Smart Agri |
| **9** | Financial reports submitted (UG /TNAU/ ITI). | Completed, Refer MN(06) Financial report | |

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| **10** | Baseline survey including gender disaggregated data/indicators, completed by the three new partners (UoN, SUA, UWI with help from UG/TNAU). | Completed<br><br>Refer MN 12 and MN 18 joint technical report | Delayed in UoN and UWI but achieved by MN 18<br><br>Data presented, gaps identified and midterm correction done in PRM Colombo detailed report in MN 18 report |
| **11** | Fine tuning of pre-harvest hexanal spray and testing with mango, banana, grapes and tender fruits demonstrations in East Africa and the West Indies (UG with UoN, SUA, UWI) | Completed<br><br>Refer MN 12,18 and 24 Joint Technical reports | Delayed in Africa due to the non-availability of hexanal but was mitigated by shipping hexanal from Canada |
| **12** | Fine tuning of hexanal based post-harvest treatments including, dip treatment for banana and grapes, vapor treatment and feasibility studies in mango, banana, grapes and tender fruits (UG-leads: TNAU, UoN, ITI, SUA, UWI) and hexanal impregnation in biowax (ITI). | Completed<br><br>Refer MN 12,18 and 24 Joint Technical reports | Though there were some delays due to season, crop failures and non-availability of hexanal in Africa, but everyone caught up and archived their targets over and beyond |
| **13** | Completion of nanotechnology approaches for 'smart packaging systems': electrospinning methodology and filing patent for wraps (UG); and invention disclosures filed for producing bio-nanoparticles from banana fibres and hexanal retention studies in bio-nanoparticles (TNAU-UG) | Completed<br><br>Refer MN 12 and MN 18 Joint Technical reports | Filed US Patent on January 15,2015<br><br>PCT/CA2015/000027<br><br>TNAU got their institutional approval to file a patent for their Nano sticker |
| **14** | Develop marketing strategy and evaluate institutional and financial options (e.g. venture capital, social enterprise funds) for commercialising technology at scale. (UG /TNAU/ITI). | Completed<br><br>Refer MN 12 and MN 18 Joint Technical Reports | Marketing strategy presented in PRM 1 in Tanzania and scale up appraised by Dr. Alvaro Paz in October 2015 at UG |
| **15** | First Monitoring and Review meeting to be held in Tanzania by August 2015 (UG /SUA). | Completed<br><br>Refer MN 12 Joint Technical Report | Meeting held in July 2015 in Tanzania, members from all team attended |
| **16** | Second financial reports for all partners (UG /TNAU/ITI). | Completed | Refer MN 12 Financial report |
| **17** | First post-harvest experiments completed and evaluation of fruit quality, shelf life and nutritional composition (All). | Completed, Refer MN 18 Joint Technical report | For UWI, SUA the experiments were ongoing during MN 18 reporting but completed few months later |

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| **18** | Evaluation of tests sites with farmers for any concerns (risks) and confirming plots for the second season trials for pre-harvest spray (All). | Completed, Refer MN 18 Joint Technical report | For UWI, SUA it was ongoing during MN 18 reporting but completed few months later |
| **19** | Baseline socio-economic analyses including gender analyses completed – South Asia, East Africa and the Caribbean - mid-term report and mid-course corrections done (UG with all partners) | Completed, Refer MN 18 Joint Technical report | Gaps identified and Mid-course correction done at PRM Colombo (May 2016), one month before the Joint report due. |
| **20** | Evaluation of commercially manufactured EFF products and feedback from growers and grower organizations (TNAU-UG). First grower interaction workshop on the effects of hexanal intervention on the economic benefits and livelihood of farmers (TNAU, UoN, SUA, UWI). | Completed, Refer MN 18 Joint Technical report | |
| **21** | Presentation of results at professional meetings such as the annual Ontario Fruit and Vegetable Convention, Niagara Falls (UG), Scientific Workers Conference (TNAU) | Completed, Refer MN 18 Joint Technical report | Conference presentations in the Research outputs. |
| **22** | Third financial reports submitted (UG /TNAU/ ITI). | Completed, Refer MN 18 financial reports | |
| **23** | Second field and post-harvest trials including hexanal vapour and wax-dipping initiated (All). | Completed, Refer MN 24 Joint Technical Report | Exciting results in Nectarine (UG), Citrus (Tanzania) and Hexanal vapour Kinetics (TNAU) |
| **24** | Production of electro-spun wraps containing hexanal for testing (UG)–to be tested in mango (TNAU, UWI, SUA, UoN), grapes (TNAU), papaya (ITI, UWI), peach (UG) and citrus (SUA). | Completed only 45%,<br><br>Refer MN 24 Joint Technical Report | Due to issues with the electrospinning machine, this could not be achieved as planned. Further, sending out the papers in mail is not as simple as originally thought and hence this will be restricted to Canada only. In TNAU Hexanal fortified Sticker and Sachet are being fine-tuned for commercial use. In all likelihood this milestone may not be achieved as planned, instead will be done only in Canada and in India |
| **25** | Initiation of registration protocols for EFF and electro-spun wraps in Canada, contact federal agencies (UG). | Completed 75% and ongoing with the licensee<br><br>Refer(Commercialization strategy Progress) in MN 24,MN 30 and MN 36 Technical reports | Registration protocols for EFF has been initiated. The licensee is expected to take it further for obtaining clearance (which is the norm in academic inventions) and we will help them with the logistics.<br><br>They had hired consultants to clear the regulatory hurdles in US also clearing the regulatory issues in South America, especially Guatemala and Costa Rica with their existing partners. Focus is more on dip as it presents relatively lesser regulatory constraints. |
| **26** | Evaluate marketing/distribution of EFF to East Africa, Caribbean and Canada (UG, SUA, UoN, and UWI). Target between 200-300 | Completed | Growers are very happy with the EFF spray and now it is being tested on pack lines (Canada). EFF has been produced and supplied |

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| | mango growers, 100-200 banana growers (India), 50 banana growers and 50 citrus growers (Africa) 25 banana growers (Caribbean) and 25 tender fruit growers (Canada) to take up the pre-harvest spray of EFF in their farms. | Refer MN 24 Joint Technical Report | to more than 120 farms (25,000 litres) covering major mango growing domains in Tamil Nadu. MOU has been signed between Smart Harvest and TNAU, so the EFF Production Pilot Plant will start functioning within 2 months to reach the commercial scale. |
| **27** | Assess scope and quality of women's participation in farm-level decision making (and related empowerment indicators). Estimate that women's participation will increase by 10-20% in all locales, due to inclusion of women in gender-aware knowledge-transfer (UG / All). | Completed<br><br>Refer MN 24 Joint Technical Report. Extensive reports by socio economist Dr. Finnis (UG), Dr. Sekar (TNAU) | |
| **28** | Preparation of bio-nanoparticle derived packaging systems for testing and shipping (TNAU-UG) | Completed<br><br>There was interruption due to human resource challenge (RA left) but resumed back with a new hire. Refer MN 24 Joint Technical Report. | Nano-fibrillated cellulose extracted from banana pseudo stem has been successfully done and a manuscript has been accepted for publication in Fibre & Polymer. |
| **29** | Presentation to grower groups in appropriate forums (ITI, SUA, UoN, UWI). | Completed over and beyond.<br><br>Refer MN24,MN30 and MN 36 reports | Project known to more than 20000 farmers during first 24 months alone. The communication was done well ahead of the target |
| **30** | Second Monitoring and Review meeting held in Sri Lanka by July 2016 (UG-ITI) | Completed<br><br>Refer MN 24 Joint Technical Report | Conducted in May 2016 @ Colombo Attended by all the team PI. their SE member and the project manager |
| **31** | Fourth financial reports submitted (UG/ TNAU/ ITI). | Completed, Refer MN 24 Financial Reports | |
| **32** | Analysis of socio-economic results from use of pre and post-harvest treatments with farmers' groups. Analysis of empowerment and capacity-building among farmers in terms of confidence with technologies, decreases in crop losses and increase in incomes (that are related to decreased losses). Projected income increases (10-15%), and related projected increases to household budget allocations to food/nutrition purchases (10%) tracked and analysed among farmer participants in South Asia and East Africa. | Completed, Refer MN 30 Joint Technical Reports | **TNAU**: Improved post-harvest management practices created about 12-17 additional days of employment during the crop season for women. Value added products made by MPG's resulted in savings in the household expenditure of between Rs. 240-Rs.270/month. ITI: Banana fibre processing unit to make fruit trays and fibre as a value added product. Processing yet to start in large scale as the construction of the facility through UNDP. UoN: Qualitative data has been collected through focus group discussions (FGDs), key informant interviews and participant observations were done UWI: Increase already noted in Lime fruit (2000 fruits/acre/week available for sale and improved marketability through increase shelf life of yellow fruit that would otherwise not be marketed |

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| **33** | Determine growers' needs regarding demand /supply and costs and apply corrective measures if necessary, to facilitate longer-term adoption of hexanal in all project locales (All). Target at least 20% of mango farmers in Tamil Nadu to take up hexanal use in the near-term. | Completed (75%),<br><br>During the main mango season 2017, TNAU has supplied more than 2000 Litres of concentrate<br><br>For additional information refer MN 30 Joint Technical Report | India (EFF Spray): Farmers are willing to pay Rs.750- 1200/acre. In 2017 Mango season 3742 farmers (of which 81% are small and marginal farmers) showed their intent to use EFF. India (EFF Dip): 120 packhouses and each one is supported by 80-100 farmers and quantity of fruits (primarily banana) treated will be 25-30 tonnes per unit per day Growers in Asia (Mango-Seasonal demand, Banana; Year around demand) and Canada want it as soon as possible. In Africa and Caribbean the acceptance is achieved from the initial reluctance. Commercial production of EFF should start at the earliest and steps have been taken by the licensee. However in Africa the major concern is on the availability hexanal. Also they prefer to have the hexanal packaged in small volumes and available at the local agrovet shops. Once the regulatory huddles are cleared by the licensee, they will bring in to Africa as the demand is created by our trials. The demand in the Caribbean farmers is very less (35%) and the market assessment is ongoing. Farmers who had done the trials or exposed to seminars had shown more interest. |
| **34** | Evaluation of results from electro-spun wraps and determining their market feasibility (UG-TNAU) | 50% Evaluation completed during MN 24 and continuing thereafter. Refer MN 24 Joint Technical Report | UG: After the issue with the machine is fixed the evaluation is done in Canada (MN 24) and is continued thereafter. Marketing is on hold. The product cannot shipped outside of Canada due to technical issues with shipping (Nano Particle excite the security screening machine). As we wait for the patent approval (USP/PCT 15/111,363), interested companies are being apprised on the intervention. Manuscript has been submitted in Polymer.<br><br>TNAU: Electrospun fibre matrix (Sticker) is ready for testing in India in commercial/field settings, which is anticipated to be done before the end of the project time. TNAU is also sorting out the shipping logistics to send them to UoN |
| **35** | Conduct large scale field trials for mangoes with 2-3 Medium/large growers and 5-10 small growers (TNAU, UoN); bananas with10 small growers and 3 packers (TNAU, UWI); citrus with 5 small/medium growers (SUA); tender fruits with 4 growers (UG); following recommended practices of regulatory agencies e.g. Canadian Food Inspection Agency (CFIA) in Canada and demonstration of quality analyses | Completed (75%) and will be ongoing beyond the project's time frame.<br><br>Refer MN30 and MN 36 Joint Technical Reports | TNAU: Large scale EFF spray on Mango and Dip in pack house (Mango/Banana) was done in July 2017UoN: Hexanal Post harvest dip trials were conducted in Meru County with 20 small scale growers SUA: Final Citrus trail was completed in July 2017UWI: Research focused on shipments of commercially available bananas and trials are ongoing. Also with small-scale lime producers. UG: The reception from growers is great as it extends the shelf life of the tender fruits by 7-10 days which fetches better prices and reduces the US imports. Exciting results in Apple but yet to confirm with one more season (Beyond the project's time frame). Awaiting for the commercial availability of the product |

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| **36** | Knowledge transfer workshops (KTW) held with mango producer groups in India and mechanisms for peer learning, knowledge diffusion between smallholder farmers identified (TNAU / UG). | Completed. Refer MN 30 Joint Technical Report | In India the three FRSCs, a total of 4360 farm advisory services were offered. Among the users about 32% of beneficiaries were farm women. 21 Value added trainings with 86% women participants (Men- 96 and women- 579). 128 EFF awareness campaigns and all 92MPG members were exposed to EFF technology. FPO for mango in process; Establishment of FPOs and linking farmers with the existing FPOs to get financial assistance from SFAC and NABARD is under way. |
| **37** | Prepare at least 5 peer-reviewed, scientific publications based on data from two rounds of field trials, especially on new crops tested – pre-harvest sprays on banana (TNAU), citrus (SUA), papaya (UWI), mango (UoN), berries (UG); post-harvest dip/vapour/wax on mango (TNAU, ITI), banana (TNAU,UWI, ITI). | Completed and achieved more than expected<br><br>8 peer reviewed Publications reported in MN 30 Joint Technical Reports | Detail list in Research output (***Annex 3***) |
| **38** | Large scale testing of bio-nanoparticle derived packaging systems with mango and banana packers/shippers (TNAU) and tender fruits growers' co-op (UG). | Completed and Refer MN30 Joint Technical Report | After two years of experimentation, nano-fibrillated cellulose (NFC) was successfully extracted from banana psuedostem. This has a unique property of UV-protection and biodegradability. This NFC with poly acrylic acid extended shelf-life of tomato by 18 days even under ambient room temperature conditions |
| **39** | Evaluation of biowax impregnated with hexanal for large scale testing by mango exporters and long distance packers (ITI). | Completed and Refer MN30 Joint Technical Report | This trial was conducted in Collaboration with Ellawala Farm and Hayleys Agriculture and repeated under observation for evaluation of results by the Department of Agriculture in Sri Lanka. |
| **40** | Fifth financial reports submitted (UG/ TNAU/ ITI) | Completed and Refer MN30 Financial Reports | |
| **41** | Thesis submissions from graduate students: 10 Masters students are anticipated to complete by this time | Completed and Refer MN 36 Joint Technical Report for the detailed list | 17 MS Thesis and one PhD submitted or defended.<br><br>At least 6 more PhD and 4 more MS thesis in the pipeline. MS thesis will be defended by mid-2018 (***Annex 1***) |
| **42** | International Conference on the use of nanotechnology in agriculture and food safety | Completed<br><br>Covered in IDRC's Asia Newsletter and Regional TV News. Refer in MN 36 Joint Technical Report. | Due to international security and logistics process instead of International conference a National conference on Nanotechnology for Ever Green Agriculture was Conducted in TNAU (October 5-6, 2017). Dr. Anindya Chatterjee, Regional director, IDRC, Asia inaugurated the conference. Dr. Kevin Tiessen, PO of the project also attended the event. |

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| **43** | Scale up and commercialization of electro-spun, Hexanal-impregnated<br><br>paper wrap production for individual fruit through licensing (UG) | Scale-up is completed (60%) with semi-pilot scale free surface electrospinning equipment.<br><br>Commercialization and licensing is premature at this time as patent is still pending with office action ongoing. | Since the activation and premature release of hexanal is a challenge, but with a hexanal precursor approach (a small add on to Sachet or label) is promising. Graduate students are working on that which will go beyond the project timeline. |
| **44** | Third Monitoring and Review meeting at Guelph in June 2017 (UG-UWI) | Completed and reported in MN 36 Joint Technical Report | Successfully completed in June (21-23) in Guelph, Ontario. |
| **45** | Sixth financial reports submitted (UG/ TNAU/ ITI). | Completed and refer in MN 36 Financial Reports | |
| **46** | Final impact evaluation including socio-economic and gender variables, and farmers' knowledge and capacities regarding the technologies, completed (UG / All). | Completed (90%), in Sri Lanka it is ongoing as waited for the product launch. Refer ***Annex 8*** | In India, by using EFF spray farmers earn additional Rs 10000 ($200)/acre and Spraying reduced post-harvest losses to distant markets by 10-12%. Data revealed that that 31% of farmers felt that EFF delayed ripening, and 51% felt it increased the premium on their products. Post-harvest dip at pack houses is performed mostly by women; this provides continuous employment for women during the season, similar view from Tanzania<br><br>In Tanzania Young women farmers will likely be more willing to adopt technologies than women over 35.<br><br>In Kenya, Farmer narrated with much confidence and joy how the use of Hexanal for his papaya farm saved him from the exploitation of middlemen and resulted into a significant increment of his Income.<br><br>In Trinidad and Tobago: The farmers were more comfortable on the GRAS certified project and eagerly await the availability of the product in Trinidad and Tobago. The main advantage of the product as expressed by farmers was the extension in fruit retention time in trees.<br><br>In Canada: After the dissemination meeting in November 2017, suggestions given by the farmers and OMAFRA staff to fast track the commercialization of the product in US and Canada. Positive feedback by apple grower. Significant progress in regulatory clearance after the meeting and the license Smart Harvest is taking care of that. |

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| **47** | Preparation of 6-8 peer-reviewed manuscripts from the work done in the project (All) | Completed this milestone in MN 30 itself. Refer MN 30 Joint Technical Report | Detail list in Research output (***Annex 3***) |
| **48** | Evaluation of company (Incubator) performance, plan expansion as needed within target countries and internationally where post-harvest losses are an issue. Work through Guelph- East Africa (GEA) in target African countries (UG). | 90% Completed, except in Africa. Refer to Commercialization update in the Final report (***Annex 5***) | The licensing is given to Smart harvest, Canada, signed a MoU with TNAU on March 15, 2018 to commercially produce and distribute EFF in the state of Tamil Nadu while they are also actively pursuing clearance for sales in other parts of the world. Canadian consul general , Bengaluru attended this event<br><br>In Sri Lanka Hayley's launched the product commercially on March 22,2018 and it is hoped that the product will be available for growers from next season. CHC, Sri Lanka attended this event.<br><br>It will take another 2 years before EFF can be produced commercially in East Africa mainly due to non-availability of Hexanal in these parts, although the governments of both Kenya and Tanzania are exploring to circumvent this. |
| **49** | End of project evaluation and impact assessment for a) pre-harvest spray of EFF (on new crops); b) biowax effect on shelf life, c) Electrospun wraps and d) Bio-nanoparticle mediated hexanal packaging. Target at least one company to produce EFF and Biowax in Asia, EFF in Africa and North America and Caribbean and 1 company to produce electrospun wraps in Asia and North America and 1 company for producing bio-nanoparticle based packaging systems. | 90% Completed, except in Africa. Refer to Commercialization update in the Final report (***Annex 5*** ) | EFF production in Asia will be done commercially soon as the MOU has been signed between Smart Harvest Canada and TNAU, Products launched with Hayleys in Sri Lanka. It will take another 2 years before EFF can be produced commercially in East Africa mainly due to non-availability of Hexanal in these parts, although the governments of both Kenya and Tanzania are exploring to circumvent this.<br><br>Electrospun wraps and bio nanoparticles have been filed for patent in India and it will take at least another year before the patent situation will be known. Thus unfortunately this part of the milestone cannot be met. |
| **50** | Large scale production of EFF (to cover 2000 acres of fruits in all countries combined), biowax, electrospun wraps – 1000-2000 sheets per crop and bio-nanoparticle mediated hexanal packaging (2500 cartons). | 90% completed except with electrospun wraps and bionano particles as their patent is pending. | In India, pre harvest spray in Mango alone reached 35000 acres, Bio wax produced 200 litres, and product launched and expected to produce 250 litres/day on demand. Refer large scale production of technologies in ***annex 9*** |
| **51** | Final project dissemination workshop | UG completed in November 2017 itself, all teams completed in multiple locations. Few teams had GAC interaction | Huge impact in Niagara Peninsula growers particularly apple growers<br><br>Canadian Consul general Bengaluru attended the TNAU dissemination event |

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| | | (with their CHC present in their event)<br><br>Refer to Project Disseminations (***Annex 7***) | Two major events in Sri Lanka followed by Product launch with their CHC presence<br><br>4-5 day event in Kenya done in a systematic way<br><br>2 day event in Tanzania<br><br>9 different meetings in Trinidad and Tobago |
| **52** | Final financial reports submitted (UG/ TNAU/ ITI). | Final stages of review and will be submitted soon | |