Accelerating genetic improvement in emerging smallholder dairy systems through fixed-time and conventional artificial insemination technologies: organizational and operational experiences from Kenya

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ILRI PROJECT REPORT

Accelerating genetic improvement in emerging smallholder dairy systems through fixed-time and conventional artificial insemination technologies: organizational and operational experiences from Kenya

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Abbreviations and acronyms

AI	Artificial insemination
AVCD	Accelerated Value Chain Development program
BCS	Body condition score
CDLP	County Director of Livestock Production
CDVS	County Director of Veterinary Services
DFA	Dairy farm assistant
CIDP	County Integrated Development Plan
FTAI	Fixed-time artificial insemination
GnRH	Gonadotropin releasing hormone
ILRI	International Livestock Research Institute
LIVES	Livestock and Irrigation Value Chains for Ethiopian Smallholders project
LH	Luteinizing hormone
ml	millilitre(s)

1. Fixed-time artificial insemination (FTAI) in emerging dairy systems in the tropics

1.1 Background

Agriculture remains the mainstay of Kenya's economy with the dairy sector contributing significantly (at least 4%) to the country's gross domestic product (GDP) (Muriuki 2011) and benefiting many smallholders that produce more than 80% of the marketed milk in Kenya (Ministry of Livestock Development 2010). The dairy sector in Kenya also provides direct employment, income and livelihood to millions of people. Most smallholder farmers own herds of between two and five cows, which are mainly crosses between indigenous zebu and various commercial dairy breeds (DGEA 2015; Ojango et al. 2014; Ojango et al. 2019). Kenyan dairy cattle population is currently estimated at 4.5 million animals with an estimated milk production of 5.2 billion litres, 60% of which is produced from an estimated number of 4.5 million exotic commercial dairy breeds and their crosses (Republic of Kenya 2019). Most (>70%) of the dairy cattle are reared by small-scale farmers in medium to high potential areas. The smallholder dairy sector in Kenya has been described as one of the most successful in Africa (Staal et al. 2008), and recently, other countries in the region have started to rely upon Kenya for the supply of breeding stock. Kenya, however, struggles to satisfy its breeding cattle and dairy product needs, with milk production mainly dependent upon rainfall and availability of forages, which fluctuates with the seasons.

Despite the promise held by the dairy sector in Kenya, most cattle in Kenya are of indigenous breeds with little potential for commercial milk producers. However, such cattle are resilient and able to withstand the harsh local environment, notably diseases, pests and low-quality and often inadequate feed resources, water included. To commercially produce milk in the tropics, rigorous husbandry, infrastructure and breed improvement campaigns need to be undertaken by various stakeholders. The dairy sector in Kenya has attained its current status as a result of many years of significant and consistent investments in disease control, farmer extension service, market development support and gradual replacement of the indigenous zebu cattle with exotic commercial dairy breeds through subsidized artificial insemination (AI) programs. The cost of subsidized AI services was initially entirely borne by the government with the assistance of international development agencies (Karugia et al. 2001; Mosi 1984). Courtesy of these initial investments, Kenya's commercial dairy sector remains one of the most developed in the eastern Africa region (ESADA 2017; IDF 2018).

Similar trends in dairy sector development are taking root in neighbouring countries in East Africa such as Ethiopia and Tanzania, where commercial dairy herds are increasingly dominated by crossbreeds (DGEA 2015; Ojango et al. 2014; Ojango et al. 2019). The trends are driven by an increase in human population and rapid urbanization that has created opportunities for farmers to respond to market-driven demand for dairy products. However, the resource constraints to livestock production in the tropics, together with the negative impact of cattle rearing on climate change necessitate keeping fewer but productive animals to meet the demand for food in a sustainable manner. Crossbreeding commercial breeds with indigenous breed types remains a logical genetic improvement option. This strategy enables combining of the dairy potential and resilience of the exotic dairy breeds and that of indigenous zebu breeds, respectively (Marshall et al. 2019; Mrode et al. 2019; Ojango et al. 2019). In some instances, introduction of new breed types such as Gyr, may be a suitable option (Madalena et al. 2012; Marshall 2014).

In many developing countries, genetic improvement and delivery of improved dairy genetics are initially and primarily financed and run by the public sector. This is also the case in Kenya where genetic improvement and delivery of improved dairy genetics in non-traditional dairy areas is supported by the county governments, often in partnerships with the private sector. County governments implement AI services as well as develop related policies and enforce regulations while the private sector mainly focuses on the delivery of these services. However, such genetic improvement programs, especially in emerging dairy areas faces several constraints that hinder successful AI outcomes. First, in smallholder systems, heat detection, which determines timing of insemination that is critical for successful AI outcomes, is a major challenge. Manifestation and observation of oestrus behaviour is difficult as most animals are stall-fed, have restricted movements, all of which limits the overt expression of heat signs by cows. Besides heat detection, other challenges to efficient AI delivery include unreliable supply of liquid nitrogen. Semen needs to be preserved frozen in liquid nitrogen to remain viable. This cold chain (i.e. availability of liquid nitrogen) is not always reliable, and where demand for AI is low, the cost of such supplies tends to be relatively high, making AI business less profitable. It is therefore common to find fewer skilled AI technicians in these areas.

Additionally, unrealistic government policies also limit technology uptake by farmers. Well-intended policies, but with under-resourced institutions and implementation processes, coupled with unrealistic subsidy frameworks for AI services are common practices that have led to failures or unsustainable AI service delivery in many developing countries. All these sum up to make the cost of AI very high and untenable when needed by the livestock keepers. Alternative strategies are thus necessary for effective delivery of AI to improve the quality of the dairy stocks in these countries, in addition to mitigating against the reproductive diseases that stem from using bulls for cattle breeding.

1.2 FTAI and justification for promoting this technology

Fixed-time artificial insemination (FTAI) is a simple reproductive technology which is cost effective and ideal for increasing the overall genetic merit of herds. As the name implies, the time to inseminate the animal is predetermined removing the need and cost associated with observation for heat signs. Candidate animals are put through a regime of timed reproductive hormone treatments and inseminated within a precise time frame without relying on observable heat signs. This enables recruitment of several animals on a farm or area to synchronize the breeding on a specified day, which massively brings down the unit cost of inseminating each animal as all the requirements are bulked and concentrated for the designated time. The FTAI protocol can be implemented on local cows, crossbreeds and improved cattle breeds. It allows service providers and farmers to plan for when to breed the animals, expect calving as well as milk production (Colazo and Mapletoft 2014).

To make business sense in conventional AI, an AI provider requires a minimum of 30 inseminations per month for their enterprise to be sustainable. The general overhead cost of liquid nitrogen remains constant whether the tank has one or more semen straws. Furthermore, the AI providers may lose up to a third of the liquid nitrogen in their tank in a month due to evaporation and other operational losses which are often passed over to the farmers, leading to the high cost in regions where only a few cows are served through AI. By scheduling several inseminations on a specific day through FTAI, the AI provider can spread the overheads, mainly the liquid nitrogen and transport, and bring down the cost of AI, making it available to farmers at an affordable cost.

FTAI is recommended for the following production systems or scenarios

1. *Emerging dairy systems with high cost of AI*: irrespective of country, in the emerging dairy areas, the population of dairy animals and AI providers tends to be low. The low demand for AI results in providers serving less than 10 cows per month. Due to low demand for AI, the animal health and feed outlets/stores tend not to stock liquid nitrogen and frozen semen. This forces the few AI providers in these areas to access AI inputs from areas

further away from their operational location, thus increasing the cost associated with the last-mile AI delivery and overall service.

2. *Emerging dairy systems with few AI technicians*: where farmers wish to upgrade their indigenous cows to improved dairy breeds, there might not be many enough inseminable number of heifers/cows to enable the pioneering dairy farmers to cost-effectively access AI services. Farmers need to pool their cows and have them inseminated by the few skilled AI technicians. Therefore, incorporating hormonal oestrus synchronization and insemination (FTAI) makes business sense for achieving improved dairy genetics.

3. *Dairy production systems with few competent AI technicians*: to further generate future business in areas where AI is not yet viable (i.e. the emerging dairy regions), proactive AI providers could procure semen and undertake planned FTAI (mass synchronization and insemination) of the many indigenous cows owned by those who wish to start commercial dairy farming. By so doing, fewer but more competent AI technicians are preferred to ensure higher conception and calving rates and thus build confidence around the new AI technology among farmers. In such circumstances, well-planned and implemented FTAI also enables large numbers of dairy calves to be produced in cohorts, thus allowing similar farmer extension messaging to be formulated and delivered to 'starters', resulting in higher heifer-calf survival and better maturation rates.

4. *Dairy systems seeking rapid upgrading and boost in milk production*: through FTAI, farmers who ordinarily would not afford AI services are able to leverage such services given the genetic superiority of AI bulls. Therefore, investing in FTAI will produce cows with improved genetic potential, including significant gains in milk production.

5. *Initiation of pedigree recording*: FTAI allows for initiation of accurate pedigree recording of the herd. Calves and heifers resulting from FTAI have accurate pedigree records, so their genetic composition is known. When these animals are sold or bought as breeding stock, this enables more structured genetic improvement programs in these areas. FTAI also enables a closer and more participatory engagement of the AI technician or breeding experts and the heifer/cow owners at the following points: a) when assessing the heifers and cows for synchronization suitability, b) during synchronization and c) at insemination. Trait selection can be discussed throughout the process in order to engage in corrective mating. For example, cows with high milk production potential but poor udder conformations can be artificially inseminated with semen from bulls with better udder and teat conformation scores, thus resulting in the improvement of total dairy merits at the herd level. In Ethiopia, 600,000 cows have been artificially inseminated with the support of the Livestock and Irrigation Value chains for Ethiopian smallholders (LIVES) project and regional governments (Gizaw et al. 2016). Using FTAI as part of its strategy, the government of Ethiopia plans to produce 5 million cross-bred heifers as part of the Growth and Transformation Plan II.

2. Organization of FTAI and stakeholder engagement

2.1 Stakeholder engagement

For successful roll out of new technologies, key stakeholders in the sector need to be engaged to achieve buy-in and active participation by the intended beneficiaries. For FTAI, achieving excellent results requires adequate engagement and good preparation by all involved. First, farmers, who in most cases have little or no experience with this technology, need to be educated on FTAI; they also need to be briefed on how to prepare their heifers and cows (Photo 1). Farmer education includes creating awareness of the tight and timely hormonal injection procedures (Photo 2) and more importantly, the need to keep the synchronized heifers/cows away from undesired bulls. As part of their contributions, farmer groups may want to build cow restraining/handling facilities, hence need to be advised on the technical requirements and guided on how to construct strong and safe structures. Clean running water needs to be available at FTAI activity sites.

Photo 1: Schedule of activities is explained to farmers by an FTAI team leader

Photo 2: Farmers patiently wait for their cows to receive reproductive hormone injection at the scheduled time

Photos 1 and 2 credit: IAEA/Victor Tsuma

When the public sector and/or development partner are involved in supporting the FTAI program, their roles need to be clearly defined and understood by all parties. For example, a local AI distribution company may be providing semen on a promotional basis and may only plan to provide semen on day 10 (day of insemination) or post initiation of the synchronization. Naturally some heifers/cows can be on oestrus on day 0, thus would need to be inseminated on that day without undergoing the synchronization procedure.

It is important to make farmers aware that not all females presented qualify for FTAI. Three possible scenarios exist when considering animals for FTAI (See Table 1)

Table 1. The domesticated FTAI program adapted by the AVCD project

Status/results	Plan	Advise
Pregnant	Not suitable for breeding	Continue with proper feeding (fodder, minerals and water) of the heifer/cow to ensure it retains the pregnancy and proper growth of the foetus
On heat (oestrus)- clear mucus discharge from the vulva	Suitable for breeding; observe the requirements	Cow should be served Best time to be artificially inseminated is 12–18 hours from the onset of heat signs (standing to be mounted, clear mucus discharge etc). NB: If the owner is not sure when the heifer/cow heat sign started it is better to recruit the cow into FTAI program but skip the Day 0 hormonal injection but continue with **day 7, day 9 culminating in AI on day 10** Observe the heifer/cow 18–24 days later for heat signs; serve any cow coming back on heat However, cows showing multiple heat signs within 18–21 days post service **must not** be served and should be examined, and the reproductive problem solved before re-breeding
Has active ovary but not pregnant (may have corpus luteum or not)	Suitable for breeding using FTAI	Recruit the animal into the synchronization/hormonal protocol **Day 0: First hormone injection of GnRH (Gonadotropin releasing hormone)** Closely observe the heifer/cow in the next 7 days, if it comes on heat artificially inseminate it. **Day 7: PGF2α injection** for heifers/cows that did not come on heat **Day 9: GnRH second injection** for heifers/cows that did not come on heat AI undertaken 16–20 hours after the day 9 injection. Hormonal injections should be done between 3–6 pm to allow earliest AI at 7 a.m. and up to 10 a.m. (assuming 16-hour duration) or spreading out to 10 a.m. to 2 p.m. (assuming 20-hour duration) *NB: Inseminate any heifer/cow coming on heat any time within the FTAI time frame or post-FTAI insemination*
Not cycling - ovaries are 'tiny' and has no corpus luteum	Not suitable for breeding	Advise the farmer to improve on feeding – proper nutrition including mineral salt supplementation Upon proper body condition score (BCS) of 2.5 the animal should be recruited in the breeding program if it is cycling

a. Pregnant cows should not be interfered with. In these cases, farmers are advised to continue with proper feeding and other good husbandry practices required for pregnant cows.

b. Cows on heat with clear mucus discharge from the vulva are excluded from FTAI synchronization but will be artificially inseminated using the a.m./p.m. rule if the owner is sure on when the heat signs started. However, where the owner is not sure on the start of heat signs, the heifer/cow should be recruited into the FTAI protocol but skip the first hormonal injection and continue with the subsequent second and third injections.

c. Animals that are in poor body condition (photos 3, 4 and 5) will most likely not conceive, even if they respond to synchronization, hence should not be recruited. The farmer is advised to improve their feeding including by giving them mineral supplements. These animals may be presented for breeding once their BCS improves. All non-pregnant clinically normal preferably cycling heifers and cows with active ovaries (palpable follicles and/or corpus luteum) should be recruited into the FTAI program (see photos 6 and 7). These heifers/cows are subjected to the reproductive hormonal injection and artificial insemination on day 10; the complete process takes 11 days (Table 3). However, depending on the ovarian cycle status (Figure 1), some of the heifers/cows may be observed on heat earlier than day 10, or following any of the injections. It should be emphasized that FTAI is not a fertility regimen. It is for planned AI in cycling or potentially cyclic animals. Therefore, cows and heifers that have unsuccessfully been bred repeatedly by bulls should not be presented, but clinically checked to evaluate their fertility.

Photo 3: BCS of 1.5

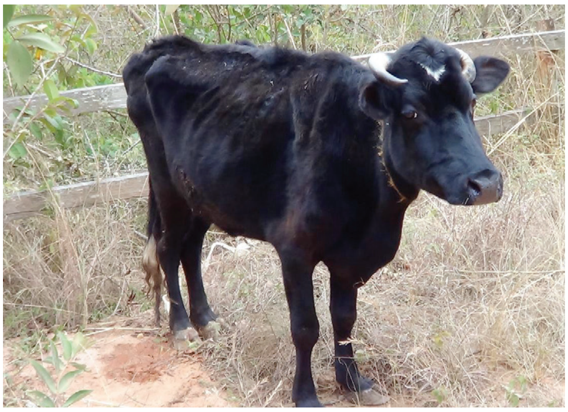


Photo 4: Cross-bred cow of BCS of 2.0

Photo 5: Cross-bred cow of BCS of 1.5

The cows in photos 3 and 4 had rough hair coats and on rectal examination, were not cycling and had small ovaries. Farmers were advised to properly feed (condition) for the ovaries to start cycling. The cows may require deworming and correction of the underlying problems. It will be a waste of hormones and time to recruit the cows into a breeding program.

Cow in Photo 5. The heifer was not cycling, with ovaries slightly bigger than the other two; it requires enhanced nutritional support to attain improved body condition to be bred. (Photos 3, 4 and 5 credit: IAEA/Victor Tsuma)

Photo 6: A zebu cow with BCS 3.0

Photo 7: A cross-bred cow with BCS 2.5

For success, the AI service provider should inform farmers to closely monitor recruited and synchronized animals for heat signs to enable timely insemination using the a.m./p.m. rule. Thorough record-keeping by both technicians and farmers will also ensure that appropriate animals are not only enrolled in the FTAI protocol, but that timely insemination is done and high pregnancy rates are achieved.

For a successful implementation of FTAI program, the following key players need to be actively involved:

i. *Farmer's representatives*: these are an integral part of FTAI as they play an important role in disseminating the relevant information on the technology and mobilizing the wider farmers' populace for the exercise. With their influence among fellow community members, they act as the entry point or the first beneficiaries of the FTAI technology. They become advocates of FTAI and rally fellow farmers to undertake the FTAI protocol, using their network to mobilize more farmers.

ii. *Government and/or development partners*: as a regulator of breeding services, the relevant government department plays a critical role in the success of FTAI. This is especially so in cases where the government partners with non-profit organizations to promote FTAI. *Government officials* include county veterinary officers who fully understand the county and subcounty livestock sector operations. These staff provide insights such as: a) who in the county is providing similar or related services and what are their capacities, b) which subcounties, wards, sublocations and villages have potential for FTAI uptake and why, and c) what are the past experiences, if any, and what key lessons could be learned from such past events. The regional/county and local district *government officials* are therefore the first line of call and are key in helping plan FTAI activities. The activities in which they are instrumental include mapping of the planned FTAI areas and facilitating/convening of planning meetings with the key stakeholders such as *farmers* and farmer organizations, AI service providers, input suppliers and *development agents* whose objectives include dairy improvement. Good rapport must be developed with the relevant subnational/county government officials. Besides facilitation, such authorities may have resources such as manpower, finances and other relevant materials that they may allocate to the FTAI work as stipulated in the respective County Integrated Development Plan in Kenya, if they are convinced that such partnerships are synergistic to their plans and therefore worthwhile.

iii. *AI technicians:* are key players for FTAI to succeed; they must be fully involved in its planning and implementation. AI technicians know the local farmers, and thus help in selecting sites for the handling pens/crushes and mapping out the planned activities. In addition, because they know what has worked and what may not have worked based on previous experience, *AI technicians* are instrumental in ensuring that past mistakes are avoided. The AI technicians, especially those with a good reputation, will successfully mobilize farmers to participate in the planned FTAI protocol, including providing guidance to farmers during every step of the protocol which culminates in an AI technician inseminating the cows. An adequate number of skilled AI technicians must be fully available over the entire period of the FTAI protocol, given that timing of FTAI service is critical, for success.

Agreement on a coordinated set of activities

FTAI is a multi-step/multistage process. For successful implementation, each stage must be properly planned and implemented in an organized and timely manner; proper coordination of processes and teamwork are critical.

Although most of the AI services in Kenya are delivered by private AI providers, these actors are regulated by the counties because agriculture is devolved to the country level. It is therefore imperative that whoever is implementing any breeding program in Kenya works closely with the respective County Directorate of Veterinary Services (CDVS). The regulatory role of CDVS includes licensing, coordinating and monitoring of the AI providers; hence roll-out of FTAI must be approved by the CDVS office, whose team then becomes an integral part of the implementation process. Besides coordinating AI services, the CDVS provides essential animal health services such as vaccinations and supervision of routine clinical treatment (this is a function which, together with AI has been privatized). The CDVS is also involved in delivery of livestock extension, which is conducted in close collaboration with the County Director of

Livestock Production (CDLP) officers. The two offices, CDVS and CDLP, are therefore involved in mobilizing farmers for technologies such as FTAI.

Like other livestock technologies, livestock extension is core to successful implementation of FTAI. Farmer education delivered via the extension systems ensures that farmers perceive net benefits to the technology, thus enhancing buy-in. Farmers must also be willing to invest time into the protocol, including separating breeding cows from bulls, close observation of their herd and record keeping. In areas where FTAI has been rolled out in Kenya, conventional AI service was not commonly adopted because of low availability and/or low conception rates. The low conception rate is partially attributed to poor heat detection and inadequate expertise that often leads to unethical behaviour by AI technicians (Baltenweck et al. 2004; Ouma et al. 2014). Farmers who have had such negative experience with AI tend to shy away from the technology. Hence the importance of effectively delivered farmer training, which is sometimes compromised by inefficiency in public extension systems. Where possible, introduction of FTAI needs to be accompanied by an enhanced extension approach managed either by the cooperative or supported by an implementing partner. In 2019, the Accelerated Value Chain Development (AVCD) program, working with six dairy cooperatives, supported a cooperative-led extension approach based on dairy farm assistants (DFAs). The DFAs offer advisory services to farmers on the benefits of FTAI alongside other improved dairy technologies. Through this training, farmers are mobilized, and their animals recruited and organized into clusters for efficiently delivery of FTAI. Through continuous advisory service engagement, cows that do not conceive from FTAI and those that calve down from the FTAI program are targeted and primed for re-breeding.

Another important consideration is the coordination of supplies for FTAI. Whether the program is financed by government or a development partner, it is important that the implementation is undertaken with the growth of the AI market in mind. To the extent possible, a private AI supply company should therefore be involved as part of strengthening AI service delivery beyond the FTAI promotion period. This ensures that the private actor is part of AI market development and will hopefully continue participating in the emerging/growing market in the long run. In Kenya, the AVCD program begun by directly handling procurement and supply of FTAI material. It later contracted a private genetics supply company, GenePlus Breeders (K) Limited, to deliver hormones, semen and liquid nitrogen for FTAI, which led to seamless supply of the necessary materials to AI service providers, thus improving overall efficiency in FTAI delivery. More importantly, this has enabled strengthening of business linkages between GenePlus Breeders and respective AI service providers, thereby guaranteeing continued supply of AI material beyond the project support period.

Overall, results obtained from the roll-out of FTAI in Kenya show that where the AI providers and the CDVS/CDLP worked closely with the project team to plan, deliver and monitor performance of the FTAI implementation, better results were achieved (see more on this in section 6). With such a coordinated effort, farmers were able to report to the two teams (AI providers and CDVS/CDLP staff) animals that came on heat as scheduled. Cows that came on heat earlier (before completing the hormonal injections) or later (soon after being served in the FTAI program) than planned or those which later showed oestrus 18–24 days post initial expected days, could also be served on time. Proper timing of insemination is beneficial to both the farmers and the AI providers as it improves confidence and trust among all the parties and increases conception rates.

Pricing of FTAI

Pricing of services and goods is driven by the market demand and supply as well as costing of the related goods and services. The pricing of FTAI services is determined by: a) costs of the key AI components (e.g. reproductive hormones, semen and AI accessories), b) transport and the mark-up, the latter being the cost of the technicians labour or arm service costs, and c) maintenance of constant level/volume of liquid nitrogen in an AI tank, which is fairly constant, irrespective of the number of AI straws in the AI cylinder. However, this cost varies depending on how frequently the tank is opened to draw out semen straws, hence the cost of liquid nitrogen must be apportioned on the AI services undertaken at any set time. With FTAI, most straws are drawn and used within the scheduled time, thus reducing this cost component. In general, the higher the number of inseminations per site, the lower the cost of the arm service, given that many heifers/cows are assembled at a designated point, so the inseminators do not have to travel to each herd to administer service. Most of the reproductive hormones are available in variable packs; the higher the dosage/volume per pack, the cheaper the unit/dosage cost. Thus, when many cows are available, the overall FTAI cost per animal is reduced.

Given the costs discussed above, part of FTAI planning requires the provider(s) to engage farmers and farmer groups to discuss and agree upon the optimum number of heifers/cows per insemination station to help reduce cost of the service.

Assigning of roles and responsibilities

For an effective FTAI program, the coordination of roles among county officials, farmers/farmer organizations, private sector and the sponsoring/delivering agent for the FTAI program is critical. Slippage by one of the parties will significantly affect those of the other and eventually the overall outcome. Past FTAI administrations had poor results attributed to activities that were ill coordinated.

Where the implementation team requires handling crushes (see Photo 14), farmers/farmer groups or the county governments may take up the role managing their construction. Farmers may provide construction materials while the county officials supervise construction. Adequate and well-constructed handling facilities promote efficient and safe cow inspection and hormonal injections.

Handling yards that enable immediate separation of heifers/cows into different categories are optimal. Up to five per cent of cows presented for initial inspection may be on heat. Such animals should be separated and withdrawn from the FTAI protocol for insemination at the optimum time (that could be the same day) following the a.m./p.m. rule. Because ascertaining the start time of such heats is difficult, such animals should be recruited into the FTAI protocol, and the first hormone injection skipped, but subsequent ones administered, culminating in AI on day 10. Therefore, even on the first day of FTAI, semen and insemination gear as well as skilled inseminators should be available to attend to heifers/cows on heat. Once such cows are inseminated, their owners are advised to keenly observe them for heat signs on days 18–24 post insemination, as they should resume cyclicity with attendant heat signs if they did not conceive to the day-10 AI. Farmers are given contacts of the local inseminators who they will call for future AI services. Record-keeping and animal identification are important; FTAI technicians should keep records of animals they have worked with and keep farmers contact information to enable timely and efficient follow-up.

A well-planned and implemented FTAI program provides the initial and critical links between farmers and local AI service providers, be they private or public. The records, if efficiently captured on a smart platform such as the African Dairy Genetic Gains-iCow (https://africadgg.wordpress.com/category/adgg/) with appropriate analytics, automatically trigger individual cow calendars and key feedback to both the farmers and AI service providers.

Also, given that some of the heifers/cows presented may be either in poor body condition, too young or pregnant; separate pens for animals to be separated into after registration are an important component of the FTAI program. Owners will be immediately provided with information on why the animals did not qualify for FTAI and advised on the appropriate course of action to qualify for recruitment during the next FTAI exercise or bred by conventional AI.

When the county or a development agency provides FTAI materials, they will be the custodian of the liquid nitrogen tank, semen, hormones, records and the reporting templates. In such cases, the subcounty veterinarian is the link between the county government and the other players. Hormones and semen require careful handling. A central and safe place is required for storage and dispensing of hormones and semen. To avoid unnecessary loss of semen, the liquid nitrogen tank must always be filled/maintained at the requisite level of liquid nitrogen to fully cover the semen; the tank must be 'topped off' whenever the liquid nitrogen drops below the critical level. A record of disbursement and use of the reproductive hormones and semen by the coordinating agent and the field team must always be maintained for accountability and to effectively monitor progress (i.e. number of animals challenged, number which show oestrus, number who are served and conception rate).

For good results, a subcounty veterinarian or their equivalent is identified and trained or refreshed on FTAI, including procedures for selecting suitable animals for FTAI. This official will coordinate all the FTAI activities at the subcounty level and will be involved directly in the selection of animals for FTAI based on body condition and uterine and ovarian findings. The inspection of each heifer/cow is critical as it determines the first level of success. The inspection process identifies healthy cows which are cycling for immediate recruitment into the protocol. It also determines and excludes pregnant animals that may have inadvertently been presented, as these could lead to reproductive wastage in addition to the embarrassment of pregnancy loss following day 7 hormone treatment. If a presented animal is identified to have a health issue, the owner is advised on the corrective measures to be taken before the animal can be subjected to FTAI. Furthermore, the initial inspection exercise determines the specific hormonal regime to which a given cow is subjected (see section 4.2).

It is these fine details and education that will lead the team to register higher conception rates above 53% that was recorded by AVCD in 2019 compared to the lower figures recorded at the beginning of FTAI promotion in 2016 in pre-commercial dairy areas of Kenya. The role of local coordination in ensuring FTAI protocol success cannot be overemphasized. Appropriate training and skills save resources through the exclusion of animals not currently suitable for the FTAI protocol. Cost is always an issue for smallholder farmers; appropriate recruitment of their animals into the FTAI protocol ensures a reasonable return on investment for smallholders, many of whom are just entering the dairy market. The subcounty veterinarian is a ‘natural’ choice for coordinating the last-mile delivery of FTAI (see section 5 for details).

3. Adaptation, training and documentation of the FTAI protocol

3.1 Selection of trainees

FTAI needs to be implemented by persons who are committed, skilled in AI and disciplined enough to strictly administer the hormonal injections and inseminate the cows at the set times. Persons charged with FTAI delivery require training and refresher courses on the theory and practice of AI and the related reproductive physiology and anatomy. A common requirement for AI technicians is training followed by registration with an authorized national body. In Kenya, the AI practitioners must be registered by the Kenya Veterinary Board, the professional organization which regulates veterinary practice. Other requirements include a certificate in animal health and production from a recognized and registered training institution. FTAI as a stand-alone service may not fully support a profitable practice; therefore, technicians/veterinarians need to be involved in offering clinical and/or other AI services to supplement their practice. An FTAI administrator requires the right attitude, commitment and drive to be able to respond to calls to action, often at odd hours. Further, they should be ready to use the synchronization program as a springboard to developing long-term relationships with farmers, most of whom may not have extensive experience with AI, and breeding program implementation and goals.

As part of introducing FTAI in pre-commercial dairy areas in Kenya, the AVCD program undertook training of AI technicians prior to rolling out the intervention. The number of persons trained on FTAI in 2016 and subsequent years is presented in Table 2 below.

Table 2: Persons trained on FTAI procedures by the AVCD project

County	Number of persons trained 2016	Number of persons trained in subsequent years
Migori	11	5
Homa Bay	5	7
Kisumu	11	5
Busia	7	3
Siaya	13	6
Vihiga	6	17*
Kitui	8	31**
Makueni	8	5
Taita Taveta	13	
Total	**82**	**79**

Note: * Trained courtesy of Welthungerhilfe (BMZ Germany) for FTAI work in Vihiga County; ** Trained courtesy of Kitui County government in February 2020 for the county-supported FTAI.

3.2 Choice of training venues

A training venue should be chosen and set in a place where trainees can access farmers who are willing to have their animals used during the FTAI training sessions (photos 8 and 9). The farmers should therefore have enough trust to allow their animals to be used for practical training sessions. To minimize damage to the reproductive tract during the training and subsequent practice sessions, the trainers must themselves be competent in AI service delivery, while those being trained should have already undergone AI training and qualification. The use of institutional animals in training sessions is ideal to avoid subjecting farmers' animals to a 'crush'; however, this is not always possible. Trainers and trainees must be aware that smallholders' animals may have not previously undergone a rectal examination; therefore, appropriately constructed crushes and handling techniques are paramount to avoid injury to animals and people.

Photo 8: Community members presenting their cows for FTAI selection.

Photo 9: Training facilitator examining the uterus and ovaries of a cow during FTAI training.

Photo 10: Taita Taveta county official opening the training session, July 2016.

Photo 11: Closure and awarding of FTAI training certificates by the County Director of Veterinary Services, Siaya.

Photo 12: One of the trainees presenting to the class in a plenary session.

Photo 13: Training facilitator presenting the lecture on FTAI, May 2016.

Photos 8–13 credit: ILRI/Laurence Ochieng

While planning for the training venue, it is important to incorporate the input of authorities from the host local government. This ensures buy-in and support and enables the implementing team to obtain valuable insight into the area. Local government officials will drive the FTAI program post-training hence the need to get them involved at the early stages of engagement. The officials will also probably be involved in selecting appropriate FTAI trainees. For instance, all persons trained in Table 2 were selected by the respective county government offices. The local government officials may be recruited to open and close the training sessions (Photos 10 and 11).

The training venue should have the requisite facilities which will enable the trainers to use the various teaching aid technologies such as projectors and flip charts to enhance the learning process (Photos 10, 12 and 13).

3.3. Who pays for the training?

To ensure commitment of trainees to the FTAI program, it is important for each participant to meet part of the training costs. However, in cases where the training is funded by a development project or the public sector, the trainees should be carefully selected based on their commitment to the program and to avoid 'free riders'. The training can also be financed by private AI firms.

Our experience shows that when trainees are selected by authorities who do not share the long-term improvement goals of FTAI, disastrous results are realized. In such cases, a lack of commitment leads to inadequate initial inspections and subsequent waste of resources when inappropriate animals are enrolled into the protocol. In addition, inseminations are not done in time and little follow-up takes place, leading to poor conception and ultimately missed opportunities for herd improvement.

4. Planning and implementation of FTAI field operations

4.1 Site planning and team set up

Designated sites are chosen for delivery of the FTAI protocol based on accessibility and acceptability by farmers and their cows. Site selection for FTAI is a collaborative effort between farmers and FTAI providers.

For effective handling of participant cohorts, the farmers will need to be organized in geographical blocks, thus avoiding the need to travel long distances. Proximity to FTAI activities is important to ensure protocol adherence and follow-up—each cow recruited into the protocol must visit the crush pen at least four times within the 11 days of FTAI initiation. The following additional factors should be considered in planning of FTAI:

i. Matching providers to crush pens: It is important to identify the FTAI providers and match them to crush pens based on their ability to access the crush pen and their rapport with the farmers. The rapport will enable the FTAI providers and the farmers to have unhindered communication. This will give the FTAI provider access to important information from the farmers which plays into the provision of FTAI. Farmers must trust providers in order to freely give a proper history of their animals. Two-way, timely communication between farmers and providers enhances conception rates.

ii. Developing a calendar of activities: The FTAI calendar is based on the number of geographical blocs, FTAI teams and crush pens. The implementation plan and calendar will avoid time conflicts (i.e. service providers being expected at different sites at the same time for hormone injections or insemination). Cases of inadequate manpower will lead to unnecessary anxiety among farmers; avoiding service provider time conflicts will prevent protocol deviations that could affect conception rates.

Farmer engagement and mobilization

Identified teams visit geographical blocs, train farmers, identify crush pen sites, confirm proposed calendars and assign mobilization teams and mechanisms (including incentive schemes, if any). During the mobilization period, crush pens are also constructed where they do not yet exist. Mobilization is effective where the implementation team works closely with lead/peer farmers that have adequate community influence.

Construction of crush pens

The construction of the crush pen or animal handling facility is to be spearhead by the community members or an assigned contractor based on the recommendation of the FTAI providers. The AI crush pen measurements are to be given by the service providers. Generally, the width will be 1.5 feet but this is dependent on cow size. Parallel crush pens as shown in Photo 14 are preferred as they ease the rectal assessment of the animal by the veterinarian as well as the AI providers during insemination. Longitudinal crushes are usually used, where cows are put in the crush pen, examined and removed; however, this tends to be a tedious process and may excite the cows unnecessarily.

Photo 14: Parallel crushes for handling animals during the FTAI protocol

Photo credit: ILRI/Laurence Ochieng

4.2 Administration of FTAI

Animal identification, inspection and management

FTAI selection is based on the body condition of the animal and its reproductive status. Any animal that has poor BCS (Photos 3, 4 and 5) should not be recruited. However, such animals should be registered, and their owners advised on how to feed them properly so that they can be presented for future FTAI procedures. Only healthy, mature, non-pregnant females that pass the first selection by having a BCS of 2.5 and above (on a scale of 1 to 5) (Photos 15 and 16) and are reproductively sound should receive hormonal injections. A team of AI technicians with a veterinarian coordinating the team should be assigned to each designated FTAI site.

The veterinarian leads and provides oversight during the heifer/cow evaluation and recruitment exercise, eventual allocation or recruitment of the cows to the subsequent hormonal regimens and all associated record-keeping. This first step is critical, as it ensures that animals are correctly assigned to the appropriate management as defined in Table 1 by sticking to the ovarian synchronizing protocol and determining whether day 0 injection is necessary or not, as it can be excluded for animals found to be on heat on this day of recruitment, but day 7 and 9 injections done.

Photo 15: A zebu x Ayrshire crossbred cow of BCS 3.5. (photo credit: IAEA/Victor Tsuma)

Photo 16: Holstein cows with BCS 4.0. (photo credit: ILRI/ Okeyo Mwai)

The cows with BCS 4 and above are usually in the following state:

- Late pregnancy
- Cycling - with corpus luteum
- Cycling - without corpus luteum

Such cows if not pregnant may be difficult to breed as they are over-conditioned (fat) and may have underlying causes which prevent conception.

Hormonal therapy

Insemination teams are constituted and coordinated to ensure each team consists of proficient and experienced AI technicians and a senior person who coordinates the team (see section 4.1 above). The selected/recruited cows are ear-tagged and digitally or manually registered into the program. The standard operating procedure for the activity consists of the following:

- All injections are intramuscularly given in the upper one third of the neck region of the animals.
- Days of the week are used to determine the injection days to avoid confusion, so that if the first injection (day 0) is on Monday, the second injection (day 7) will occur the following Monday. The third injection (day 9) is given two days after the second injection (i.e. Wednesday): insemination occurs 16-20 hours after the third injection (on Thursday) (Table 3). The days and dates are recorded for each cow and a copy of each record is shared with the heifer's/cow's owner. The injections should be given from 3 p.m. onwards. Early injection may peg the appropriate insemination time at night hours that are not workable.

Table 3: Hormonal injection and insemination schedule using the Ovsynch protocol for FTAI with reproductive hormones from Bimeda, Kenya

Week	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1		1 ml* GONAbreed®					
2		2 ml estroPLAN®		1 ml GONAbreed®	AI 16–20 hours after Wed injection		

*ml = millilitre(s)

- Each of the three injections for each animal are performed at the same time of the day and the action duly recorded.
- No injection is given before 4 p.m. to ensure that logistically and practically, the earliest insemination would occur at 8 a.m. on day 10 (i.e. target an optimum period of 16 hours between the last injection and insemination but allowing for up to 18 hours).

Several GnRH preparations are on the market. In the Kenya program, we used GONAbreed® and the prostaglandin F2α (PGF2α) preparation used was estroPLAN®.

For animals that require three hormonal injections, before an insemination, below is the summary of the injection schedule:

Day 0: 1 ml of GONAbreed®

Day 7: 2 ml of estroPLAN®

Day 9: 1 ml of GONAbreed®

Day 10: insemination (i.e. ideally 16–20 hours after day 9 injection)

Note that:

- Only healthy animals with a BCS of 2.5 to 4 (on a scale of 1–5) should undergo the hormonal treatment only if not pregnant or no uterine problems.
- To avoid confusion, if day 0 is a day of the week, day 7 will be same day of the following week, and day 9 two days later. For example, if day 0 is Monday, day 7 will be Monday the next week and day 9 is Wednesday with insemination on day 10 which is Thursday (Table 3).
- All injections should be administered at the same time on the respective treatment days.
- The earliest time for hormonal administration should be 4 p.m. on a given day to allow for the earliest insemination time to be 8 a.m. on the day of insemination.
- Animals which undergo the full set of three hormonal injections should be inseminated on day 10, regardless of having been seen on heat or not.

Insemination

For good results, insemination must be done on the designated day and time (i.e. on day 10 for those heifers/cows that underwent the full FTAI therapy - Table 1). Proper preparation must be done prior to insemination such as thawing of the semen (Photo 17) and loading into the insemination gun (Photo 18). Thawing of semen is important as it activates the frozen spermatozoa to swim through the female reproductive tract towards the ovum for fertilization. The inseminator ensures semen is deposited into the uterine body by navigating through the cervix; this can only happen when the animal is on heat and the cervix is open (Photo 19).

For purposes of follow-up, it is important to record the details of the bull (Photo 20) and that the farmer is given the AI straw for their own records. Recording enables the AI providers, farmers and the semen providers to identify the various aspects of a bull, which will inform future selection processes such as productivity and other desired traits.

Post-insemination farmer engagement

Post-insemination management of cows is critical. Cows and heifers need to be adequately fed, receive balanced mineral supplements and should be free of extreme stress. Feed inadequacy, extreme ambient temperatures and humidity and disease can cause early pregnancy loss, and thus lower conception and calving rates. Often such losses are mistakenly attributed to FTAI failures.

All the animals which receive the three reproductive hormonal injections are inseminated irrespective of whether they show signs of heat. However, in a dairy herd, animals tend to be at different stages of the ovarian cycle as shown in Figure 1 and 2; therefore, not all animals will appropriately respond to the exogenous reproductive hormonal therapy within the anticipated time frame. Therefore, upon insemination, farmers should observe these animals for signs of heat, which indicate the need for re-insemination.

Farmers should be aware of the following scenarios and contact the AI provider immediately for the animal to be inseminated:

- *Day of recruitment*: any animal coming on heat must be removed from the FTAI protocol and be inseminated on that particular day as this is naturally occurring fertile heat induced by the endogenous reproductive hormones within the ovarian cycle. However, the owner must be sure as to when the heat signs started; if not sure the heifer/cow should be recruited into FTAI program but skip the first hormone injection, continuing with the rest of the FTAI protocol.

- *Heat signs observed within days 1–9*: must be served as the exogenous hormones might have 'quickened' the ovarian cycle for the ovulation to occur.
- *FTAI post-insemination heat signs*: these animals will need to be inseminated once they come on heat despite being served on day 10 of the FTAI protocol.

The post-insemination engagement with the farmers will help to enhance the conception rate as explained in Section 6.1. For successful FTAI, the key players—that is the farmers and the AI providers—will need to be in constant communication to ensure all animals coming on heat are served on time.

Photo 17: AI providers thawing the semen before loading it into the AI gun for insemination.

Photo 18: AI provider loading semen into AI gun.

Photo 19: An AI provider inseminating a heifer; his left hand is grabbing the cervix as he navigates through the cervix to deposit the semen in the uterus.

Photo 20: An AI provider entering the semen details in the recording book.

Photos 17–20 credis: IAEA/Victor Tsuma

The post-insemination engagement with the farmers will help to enhance the conception rate as explained in Section 6.1. For successful FTAI, the key players—that is the farmers and the AI providers—will need to be in constant communication to ensure all animals coming on heat are served on time.

5. Record-keeping and follow-ups

AI providers will be involved in hormonal administration based on the agreed hormonal regimen as per the ovarian findings. They will undertake the inseminations as required and advise the farmers accordingly on the right breeds/ bulls for their cows. The AI provider is expected to leave their contact information with the farmers so that they can be reached if the cow comes on heat prior to schedule and requires immediate insemination outside the prescribed hormonal schedule. The AI provider needs to be in constant consultation with the veterinarians as well as the farmers/farmer groups for them to adopt the necessary changes in management of cows which might require special attention to enhance conception rates

The AI providers: are expected to train/offer extension to the farmers on appropriate animal husbandry prior to breeding their cows. Extension services include advice on animal care during the period around breeding and post-breeding, calving, management of calves/heifers and preparation of heifers/cows for breeding.

Farmers and farmer groups: for success of AI or FTAI programs, the farmers must play an active role in the whole set up. Their role includes, but is not limited to, preparing the animals for breeding (proper feeding and disease control), presenting their cows for breeding/re-breeding, contacting and planning with the AI providers on a breeding program and follow-up of the FTAI protocol. They also ensure dates and times and details of sire identities and breeds and births resulting from FTAI services are recorded.

6. Results and lessons learned

In this section, we present and discuss results from the pioneer FTAI intervention in the pre-commercial dairy areas in Kenya. We look at the result in terms of conception rates achieved over time and discuss adjustments that enabled improvement in results. We conclude the section by a discussion on key lessons learned that can inform the roll-out of similar initiatives elsewhere.

6.1 Results obtained: Levels of conception rates achieved

To discuss the results, we classify the FTAI roll-out into three waves/phases: 2016, 2017/18 and 2019/20.

Phase I of FTAI – 2016

The initial FTAI work under the AVCD program in 2016 was performed during training of AI providers and veterinarians in Siaya, Taita Taveta and Migori counties. A mix of service providers was trained and were generally overzealous in the field work, strictly adhering to the 10 days FTAI protocol with very little regard to:

a. serving/inseminating animals on heat during recruitment, and

b. ovarian status of animals at presentation; all heifers/cows presented to the team which were not pregnant were recruited into the 10 days protocol without due consideration of the ovarian status of the animals.

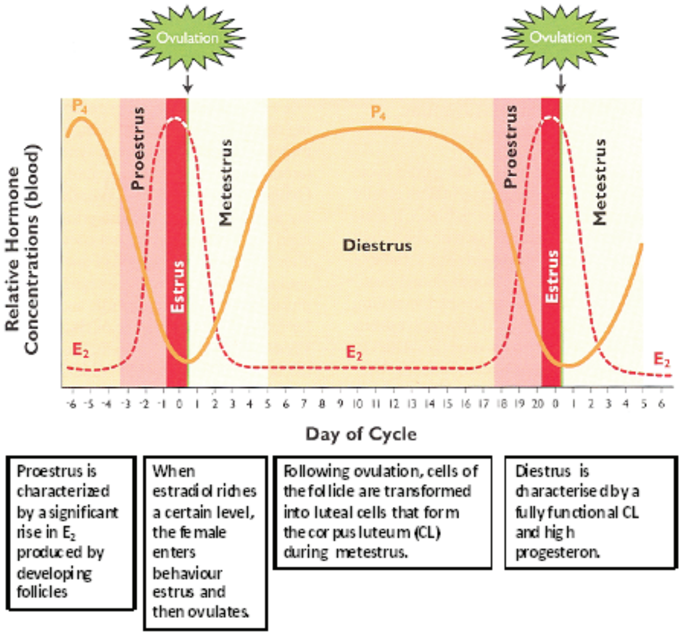
Table 4: Results from the initial FTAI carried out in the nine counties in Kenya, 2016

County	Number of cows inseminated	Conception rate (%)
Kisumu	719	40.9
Migori	592	35.6
Vihiga	2,210	20.5
Taita Taveta	551	24.2
Homa Bay	1,002	24.7
Siaya	395	24.4
Makueni	289	36.4
Busia	25	60.3
Kitui	55	35.2
Total	**5,838**	**33.6**

There were, however, some exceptions to these shortcomings. In some FTAI centres in Migori, animals which came on heat after day 10 (post-FTAI insemination) were served by dedicated institution AI provider at the Lake Basin Development Authority (LBDA) farm at Lichota; hence the superior conceptions seen in Migori County (Table 4). For other counties such as Homa Bay and Vihiga, a large pool of geographically dispersed heifers/cows were enrolled in the protocol, but it was not feasible to access the animals at the prescribed time either during hormone injection or insemination. This therefore led to some animals falling off protocol including failure to receive the full hormone injection treatment and failure to inseminate cows on heat at any stage of FTAI treatment, including post-insemination.

For other counties such as Kisumu, Makueni and Busia, the FTAI protocol kicked off later than in the other five, hence they were able to learn from these experiences. These lessons were shared with the relevant authorities during meetings organized to follow-up on FTAI training and pregnancy assessments. This therefore led to well-planned and coordinated execution of the FTAI protocol. In Makueni, FTAI was implemented through a cooperative society, Kikima Dairy; in Kisumu, Kitui and Busia, FTAI was taken up by individual farmers as well as farmer groups who were in constant communication with a dedicated AI providers team. At these sites, any cow coming on heat during the FTAI protocol was served irrespective of the planned hormonal injection.

Figure 1: Cow oestrus cycle (Husveth 2011)

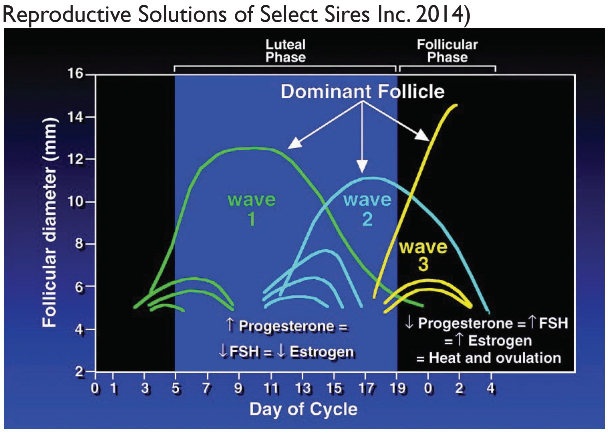


Arising from lessons learned in the first year of the FTAI work in 2016, several adjustments were made in the subsequent FTAI protocol to achieve maximum conception. The emphasis was on a better understanding of the cow's reproductive hormonal interplay and the effect of exogenous GnRH and PGF2α. Generally, the cow's oestrus cycle is subdivided into two phases (Figures 1 and 2) based on the dominant hormone or ovarian structure during each phase (Select Reproductive Solutions® 2014). The luteal phase begins when the corpus luteum is formed about five to six days (Figure 2) after the cow is in heat, and ends when the corpus luteum regresses, about day 17–19 of the cycle. Ovarian follicles may be present on the ovaries throughout the oestrus cycle and the follicular growth occurs in 'waves' (Figure 2).

Normally, an animal will have two or three waves of follicular growth during a 21-day cycle. The beginning of each wave is characterized by a small rise in the follicle stimulating hormone (FSH) followed by rapid growth of numerous follicles. From this wave of follicles, one follicle is selected to grow to a much larger size than the others. This 'dominant' follicle can regulate or restrict growth of all other follicles on the ovary. Dominant follicles only remain dominant for a short period of time, three to six days, which is followed by either cell death and regression or ovulation and release of the egg. Consequently, the disappearance of the dominant follicle coincides with recruitment of the next wave of follicular growth. From this new wave, another dominant follicle is selected. Although it is typical for much follicular growth to occur throughout the oestrus cycle, low levels of luteinizing hormone (LH) during the luteal phase prevent these follicles from producing high levels of oestrogen which would bring the animal back into heat. It is only the dominant follicle present at the time the corpus luteum regresses, when progesterone levels are low, that produces enough oestrogen to bring the animal back into oestrus and to ovulate.

From the understanding of the reproductive hormones and their interplay, the FTAI project team mandated the addition of a veterinarian with a good understanding of the ovarian, uterine and general reproductive tract of a cow to help in the selection and recruitment of the cows for FTAI. The veterinarian required to perform a thorough examination of the heifer/cow uterine status, that is to examine the cow's uterus to determine if it is fit for conception. If a uterine problem is detected, it is treated prior to presenting the cow for recruitment into the breeding program. The veterinarian also

Figure 2: Reproductive anatomy and physiology of a cow (Select Reproductive Solutions of Select Sires Inc. 2014)



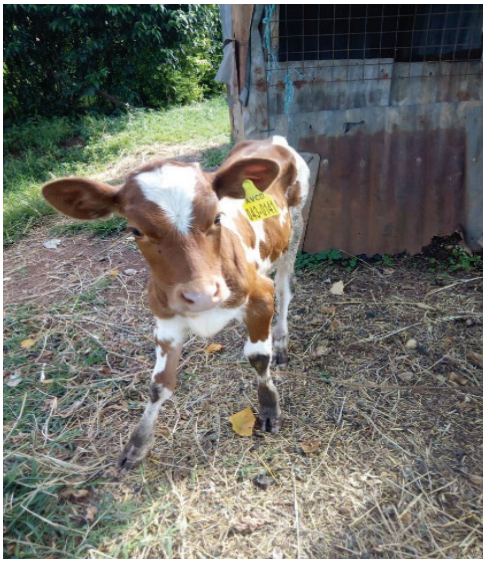
examines the heifer/cow ovary cyclic status (Figure 2). An evaluation of the cow's ovaries and uterus helps the FTAI team create an optimal breeding program as stipulated in Table 1.

Apart from the ovary and uterus examination, the FTAI team (veterinarian and AI providers) use the BCS (Photos 15-16) to select heifers/cows for inclusion into the FTAI protocol.

Phase II of the FTAI protocol 2017/18

As part of the FTAI team, AI providers work to enhance their interaction with the individual farmers or farmer groups, whereby any animal coming on heat is reported to them on time and is served irrespective of the planned hormonal protocol. The AI providers offer the necessary extension information to farmers on heat signs and insemination timing and management of in-calf cows, pregnant or not. Good interaction with farmers by the entire FTAI team builds farmers' confidence in AI services and the FTAI protocol.

Photo 21: A product (calf) of FTAI, the ear tag has a county code developed in collaboration with the respective county government. (Photo credit: William Omolo)



The farmers are expected to mobilize more of their peers to adopt the FTAI program. Recruitment of more heifers/cows into the FTAI program at any given time reduces the operational costs of the FTAI teams such as transport and arm services. Further, the farmers must inform the AI providers of any animal coming on heat during the FTAI protocol duration or post-insemination (repeats) for them to be served on time, hence improving the conception rate.

For effective and well-coordinated FTAI work, the county government needs to be actively involved. In most of the counties where AVCD implemented the FTAI program, the only available veterinarians were county employees and they were involved in coordinating the FTAI work at the county and subcounty levels. The subcounty veterinary officers and/or the private veterinarians formed the FTAI team at the subcounty level and supported the FTAI team in recruitment of cows through the ovaries and uterine examination. The county government offices near the AI providers and farmers acted as the focal point for storage and disbursement of liquid nitrogen and semen to the AI providers. The county government acted as the link between the county/subcounty FTAI teams and the development partner implementing the intervention such AVCD/International Livestock Research Institute (ILRI). The county government coordinated disbursement of hormones, semen and liquid nitrogen and collected the FTAI reports/data and forwarded the information to the development partner. This led to the overall improvement in conception as shown in Table 5. Overall, all counties improved their conception between 2017 and 2018, which reflects the improvements in coordination and experience acquired by AI technicians over time.

Table 5: Results after FTAI implementation in 2017–18 in nine counties of Kenya

County	Number of cows inseminated		Conception rates (%) achieved/recorded	
	2017	**2018**	**2017**	**2018**
Kisumu	1,646	924	42.86	55.01
Migori	40	101	41.7	41.95
Vihiga	1,574	200	35.6	42.03
Taita Taveta	99	44	42.11	53.01
Homa Bay	229	194	43.21	45.01
Siaya	510	156	41.86	54.24
Makueni	393	303	53.26	48.62
Busia	685	163	46.71	54.21
Kitui	41	0	42.83	-
Overall performance	**5,217**	**1,961**	**43.34**	**43.78**

Phase III of the FTAI protocol in 2019/20

In 2019, the AVCD program scaled down its operations to focus on cooperatives as the key entry point into communities as opposed to its work in the initial phase where everything was coordinated at the county level. The intention was to enhance capacity of dairy cooperatives to spearhead market-led growth of the dairy sector. Consequently, FTAI work was coordinated at six dairy cooperatives in Nyanza and two others in Makueni County. Drawing from lessons from the initial phase of AVCD, each cooperative had dedicated staff in the name of dairy farmer assistants (DFAs), whose responsibility included recruitment of animals for breeding and sharing other improved dairy technologies disseminated by the program. The main responsibility of DFAs is to deliver advisory services to farmers, empowering them with the knowledge and thus improving their decision-making on technology uptake. Besides mobilizing farmers for technologies adoption, the DFA structure provided opportunity for follow-up of FTAI interventions and ensured animals coming back on heat post the FTAI protocol were re-inseminated. This resulted in marked improvement in average conception rate – 59.97% (see Table 6), compared to the previous years where the average conception rate was 43.34% and 43.78% in 2017 and 2018, respectively. A key observation was that more than half of the animals that came on heat during or immediate post-FTAI insemination were served.

Table 6: FTAI results obtained for animals bred between September and December 2019

County	Cooperative	Cows inseminated	Conception rates (%)	Comment
Homa bay	KASBONDO AIM	120	75.00	One animal died, 12 were sold and 1 aborted
	Rangwe Dairy Coop	149	59.09	One animal died and 8 were sold
Migori	Rongo Dairy Coop	113	53.19	Two animals were sold
Siaya	SAM-Malanga Dairy Coop	369	53.02	
Kisumu	OSIEPE Practical Action	130	59.01	Seven were sold, 50 of the animals were not pregnant
	SEKE Farmers Coop	82	60.52	One died, two sold and two stolen
Average			59.97	

The conception rates obtained from the work in Kenya in 2019, 53–75%, were at par with those obtained from similar programs in Ethiopia, where conception rates between 53.9 and 69.9% were recorded, depending on bulls used (Belay et al. 2016), whereas the ones for 2017 and 2018, with an average of 43%, were good and are close to the average pregnancy rates of 40% that is reported for conventional AI programs elsewhere (De la Sota et al. 1998; Kenya National Artificial Insemination Services; Shamsuddin et al. 2001; Shikder 2011; Woldu et al. 2011).

FTAI protocols used in lactating dairy cattle have resulted in pregnant rates similar to those of AI after oestrus detection (De la Sota et al. 1998; Pursley et al. 1997). However, conception rate may be lower when such protocols are used, as ovulation may not be adequately synchronized in about a third of treated animals. A small proportion (11%) may ovulate before the FTAI, few (15%) may not respond to PGF2α, whereas some (9 %) may not ovulate after the second GnRH (Colazo and Mapletoft 2014). Cumulatively, the synchronization rate is thus about 68%. Considering a service to conception rate of 1.6 (the recommended interference level reproductive index) together with a synchronization rate of 68%, a 42.5% conception rate is expected in animals on FTAI.

6.2 Key lessons learned

From the results of the initial FTAI protocol implementation and the subsequent protocol adjustments in 2017–18 FTAI, the following lessons were evident:

1. It is apparent that the BCS of the heifers/cows at the time of FTAI and immediately after had a huge impact on conception. Heifers and cows in good body condition and improved plane of nutrition performed better than those that were not in good body condition. For example, at a medium-scale farm in Kuria West, Kuria

County, six out of 11 cows that underwent FTAI conceived on first service, while the other three conceived following natural oestrus (i.e. without using hormones). Of the remaining two cows, one was sold off, so was not trackable, while one seemed to be a difficult breeder and never conceived. Pregnancy diagnoses and ovarian examination revealed that most cows that were in poor body condition were not pregnant and were anoestrus with small ovaries and were not cycling hence could not conceive even when subjected to reproductive hormone injection to stimulate heat. Therefore, for an animal to be served, it should be in good body condition to positively respond to the hormones.

2. Commitment by the key players—AI providers, veterinarians and farmers—is crucial. When each of the players shows total commitment such as farmers timely reporting observable heat signs and the AI provider responding as requested and per protocol, the conception rates were impressive. For example, in Busia in 2016, one of the inseminators showed total commitment and strictly followed the protocol, leading to a record 60% conception rate.

3. The initial overall low conception rates in 2016 were primarily attributed to poor animal selection, inaccurate timing of the hormonal administration, failure to inseminate cows coming back on heat after the initial selection and subjection of all animals to a blanket three hormonal regime and subsequent insemination at 16–18 hours. It is important to note that in a herd of cattle, each animal is in a different ovarian cycling stage hence the need to be on the lookout and serve any cow that comes on heat at any time within the 10 days the FTAI is undertaken irrespective of the prescribed schedule.

4. Where the government (regional or national) or partners are funding or supporting FTAI implementation, it is important that all the players agree on how to run the process taking into consideration the available manpower, resources, geography and seasonality when most of the cows are in appropriate good body condition for breeding.

5. To spread the FTAI costs and to keep the costs down, aggressive awareness creation and mobilization of farmers is required so that enough animals (i.e. 25–50 cows per FTAI centre) are made available for initial examination and recruitment.

6. It is critical to ensure that the highest level of biosecurity, safety and hygiene standards are maintained at the FTAI centres during FTAI implementation to mitigate the general unwillingness of farmers already rearing ‘grade’, hence more expensive and vulnerable animals, to take their animals to a common FTAI centre. Where distance and time allow, handling facilities exist, and owners can pay; such animals need to be handled in respective farmers’ homes.

7. Some AI providers may lack adequate hands-on AI experience and even after undergoing refresher training, such technicians need to be mentored by their more experienced colleagues. It is important to ensure that each FTAI team has skilled and experienced members to maximize overall FTAI outcomes and success.

6.3 Challenges

The following are the key challenges that were encountered during FTAI implementation:

1. Failure of the farmers to strictly adhere to the FTAI protocol (hormonal treatment and AI). Some of the recruited animals skipped some of the prescribed three hormone injections and subsequent insemination or altogether pulled out of the FTAI protocol. Failure to adhere to the protocol necessitates that the animal is recruited afresh, which is unaffordable to many poor farmers targeted with this technology.

2. Some of the recruited heifers/cows were not separated from the bulls, hence when they came on heat, they were served by the unintended village bulls.

3. Inexperience or incompetence of local service providers in ovarian/uterine examination and insemination led to poor animal selection and low conception rates. Many of the local FTAI providers did not regularly practice

ovarian/uterus examinations which led to recruiting inappropriate animals, such as those in poor body condition, already pregnant with the protocol causing abortion, or misdiagnosis of pregnancy and therefore exclusion from FTAI. Prior to FTAI protocol implementation, every member of the team should undergo training and evaluation, including practical sessions on the related reproductive principles and FTAI procedures, and only those who prove to be competent receive certification and a license to practice FTAI.

4. Lack of total commitment or inadequate planning by AI practitioners, including failure to adhere to strict timing of the hormonal administrations and inseminations, leads to low conception rates. Failure to adhere to the FTAI protocol, which includes exceptions to hormone injections and insemination, or re-insemination timing based on observable signs of heat contributes to FTAI failure and loss of farmers' trust in the FTAI team and technology.

5. Animal factors can provide significant, but mostly avoidable challenges. Heifers and cows that are in poor body condition (i.e. BCS of less than 2.5) during and immediately after FTAI will not conceive. Nutritional challenges, inadequate energy and mineral imbalance cause the ovaries not to cycle and cannot be corrected with hormonal therapy. Animals with infected reproductive tracts or cystic ovaries will not conceive following FTAI.

6. Handling facilities such as crushes are important wherever one sets to examine or inseminate an animal. Without proper handling facility the animal might get excited posing danger to the AI provider, the farmers as well as the animal itself or stoppage of the AI exercise. Most of the community members lack crushes hence curtailing the smooth running of the FTAI/AI work. This makes the AI provider/s struggle with the animal while undertaking their work see photo 6.2.

Photo 22: One of the cow's being inseminated on day 10 by an AI provider. Lack of animal restraining structures is a main challenge in the community (photo credit:ILRI/Laurence Ochieng)

Photo 23: A cow bred using FTAI with its calf (Photo (photo credit:Vincent Ogola)

7. Recommendation and implications

Based on our experience and through interactions with the key actors in practical FTAI delivery in emerging dairy systems in Kenya, we recommend the following:

i. For best results, FTAI is best undertaken by a team which includes a veterinarian and an AI technician. The veterinarian is responsible for selection of animals to be bred by individually examining each candidate heifer/cow, first by scoring the animal for suitability based on BCS, then thorough ovarian and uterine palpations to establish the reproductive status of the animal. Resourcing to support this critical process is well worth it and should be factored into the FTAI planning and implementation.

ii. For success, FTAI requires a high degree of dedication and preparedness, and the AI providers and farmers must be closely linked. Telephone contacts and the FTAI records must be shared with farmers and the FTAI technical coordinator for efficient follow-up of hormonal treatments and inseminations. In addition, animals enrolled in the FTAI protocol must be kept away from undesired bulls.

iii. Provisions must be made for animals that show obvious oestrus signs on day 0 to be immediately inseminated upon detection, and thereafter put on the follow-up list for subsequent oestrus signs and insemination plans.

iv. Previously, all the animals were subjected to three hormonal treatments (i.e. day 0, day 7 and day 9 followed by insemination on day 10) irrespective of the oestrus cycle stage of the cow. This approach is wasteful and it is more appropriate for the veterinarian and AI teams to anticipate and prepare for earlier inseminations (i.e. any animal coming on heat is served as soon as detected irrespective of the stage of hormonal therapy) (Table 1).

v. To ensure cost-effective FTAI delivery, at least 20 cows should be recruited for each site; hence an adequate number of farmers should be mobilized. Maximal enrollment of cohorts brings down costs per animal. The service providers will be paid for the four days visits to the FTAI crush sites on day 0, day 7, day 9 day 10 and on follow-up visits.

8. References

Baltenweck, I., Ouma, R., Anunda, F., Mwai, O. and Romney, D. 2004. *Artificial or natural insemination: the demand for breeding services by stallholders*. 9th KARI (Kenya Agricultural Research Institute) annual scientific conference and agricultural research forum. Nairobi, Kenya.

Belay, D.L., Tera, A. and Tegeng, A. 2016. Evaluating the efficiency of artificial insemination following estrus synchronization of dairy cattle in southern region, Ethiopia: The Case of Dale District. *Journal of Natural Sciences* 6(5): 22–27.

Colazo, M.G. and Mapletoft, R.J. 2014. A Review of current timed-Ai (Tai) programs for beef and dairy cattle. *The Canadian Veterinary Journal* 55(8): 772.

De la Sota, R., Burke, J., Risco, C., Moreira, F., DeLorenzo, M. and Thatcher, W. 1998. Evaluation of timed insemination during summer heat stress in lactating dairy cattle. *Theriogenology* 49(4): 761–770.

DGEA (Dairy Genetics East Africa). 2015. Project report. Dairy Farm baseline survey report for Tanzania and Ethiopia: Https://Ilri-Angr.Wikispaces.Com/Dgea%201.

ESADA (East and Southern Africa Dairy Association). 2018. East Africa Dairy Manufacturing Markets 2018.

Ferenc, H. 2011. *Physiological and reproductional aspects of animal production*. Debreceni Egyetem, Nyugat-Magyarországi Egyetem, Pannon Egyetem.

Gizaw, S., Tesfaye, Y., Mekuriaw, Z., Tadesse, M., Hoekstra, D. et al. 2016. *Oestrus synchronization for acelerated delivery of improved dairy genetics in Ethiopia: Results from action research and development interventions*. LIVES Working Paper 12. Nairobi, Kenya: International Livestock Research Institute (ILRI).

IDF (International Dairy Federation). 2018. Annual report 2018–19.

Karugia, J.T., Mwai, O.A., Kaitho, R., Drucker, A., Wollny, C. and Rege, J. 2001. *Economic analysis of crossbreeding programmes in sub-saharan africa: a conceptual framework and kenyan case study.* Nota di Lavoro, No. 106.2001. Milano: Fondazione Eni Enrico Mattei (FEEM).

Kenya National Artificial Insemination Services. (year of publication). Annual Reports: 1982–1992. Ministry of Livestock Development, Department of Veterinary Services.

Madalena, F., Peixoto, M. and Gibson, J., 2012. Dairy cattle genetics and its applications in Brazil. *Livestock Research for Rural Development* 24(6): 1–49.

Marshall, K. 2014. Optimizing the use of breed types in developing country livestock production systems: A neglected research area. *Journal of Animal Breeding and Genetics* 131(5): 329–340.

Marshall, K., Gibson, J.P., Mwai, O., Mwacharo, J.M., Haile, A. et al. 2019. livestock genomics for developing countries–African examples in practice. *Frontiers in genetics* 10: 297.

Ministry of Livestock Development. 2010. Kenya National Dairy Master Plan. Government of Kenya:

Mosi, R.O. 1984. *The Use of milk records in cow evaluation and dairy cattle improvement in Kenya*. Bangor: University of Wales.

Mrode, R., Ojango, J.M., Okeyo, A. and Mwacharo, J.M. 2019. Genomic selection and use of molecular tools in breeding programs for indigenous and crossbred cattle in developing countries: Current status and future prospects. *Frontiers in Genetics* 9: 694.

Muriuki, H. 2011. *Dairy development in Kenya.* Rome, Italy: Food and Agricultural Organization.

Ojango, J.M., Marete, A., Mujibi, F., Rao, E., Poole, E.J., Rege, J. et al. 2014. *A novel use of high density snp assays to optimize choice of different crossbred dairy cattle genotypes in smallholder systems in East Africa*. American Society of Animal Science. https://hdl.handle.net/1959.11/19794

Ojango, J.M., Mrode, R., Rege, J., Mujibi, D., Strucken, E. et al. 2019. Genetic Evaluation of test-day milk yields from smallholder dairy production systems in Kenya using genomic relationships. *Journal of dairy science* 102(6): 5266–5278.

Ouma, R., Jakinda, D., Magati, P. and Rege, J. 2014. *Benchmarking the Kenyan artificial insemination service sub-industry. A study for the Kenya Markets Trust and the Competition Authority of Kenya*. Nairobi, Kenya: Kenya Markets Trust.

Pursley, J., Wiltbank, M., Stevenson, J., Ottobre, J., Garverick, H. and Anderson, L. 1997. Pregnancy Rates per artificial insemination for cows and heifers inseminated at a synchronized ovulation or synchronized estrus. *Journal of dairy science* 80(2): 295–300.

Republic of Kenya. 2019. Economic Review of Agriculture (Era).

Shamsuddin, M., Bhuiyan, M.M.U., Sikder, T., Sugulle, A., Chanda, P. et al. 2001. *Constraints limiting the efficiency of artificial insemination of cattle in bangladesh*.

Shikder, A. 2011. *Post AI pregnancy rate of crossbred and zebu cattle using frozen semen at Debhata and Kaligonj Upazilla in Satkhira District.* MS in theriogenology Thesis. Department of Surgery and Obstetrics, Faculty of Veterinary Science, Bangladesh Agricultural University, Mymensingh.

Staal, S.J., Nin Pratt, A. and Jabbar, M. 2008. *Dairy development for the resource poor. Part 2: Kenya and Ethiopia*. Dairy Development Case Studies.

Woldu, T., Giorgis, Y. and Haile, A. 2011. Factors affecting conception rate in artificially inseminated cattle under farmers condition in Ethiopia. *Journal of Cell and Animal Biology* 5(16): 334–338.

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